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**PREPARATION OF MATRICES FOR THE
PUBLICATION OF MAPS**

**Isgotovleniye Pechatnykh
Form Dlya Izdaniya Kart**
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PREPARATION OF MATRICES FOR THE PUBLICATION
OF MAPS

PART I
PHOTOGRAPHIC PROCESSES

CHAPTER I

FUNDAMENTALS OF THE PHOTOGRAPHIC PROCESS

1. Action of Light on the Photographic Emulsion

Light plays a very important role in all the photomechanical processes upon which modern map publishing is based. Thanks to the effect of light on photographic emulsions it is possible to obtain and to fix on a photographic plate an image of the original of the map, produced by the cartographer, and also to obtain printing forms with which to duplicate the maps in any number of copies. Using light for the formation of the image makes it possible to do in a few minutes what previously consumed months and years of painstaking work.

It is known that images can be duplicated in different ways, one of which is emission of light. Energy transmitted by emission of rays (radiant energy) is used for the formation of the image.

Light does not affect the retina of the human eye and the photographic light-sensitive emulsion in an equal manner. The human eye sees the yellow portion of the spectrum as the brightest, while the photographic light-sensitive emulsion reacts most intensely to the blue and violet portions of the spectrum. There are equations with which it is possible to calculate the so-called relative visibility, i. e., the quantity showing by how much more intensely rays

With different wavelengths (λ) act on the retina of the human eye. If these data are used to plot a curve for the eye, it will assume the form shown in Figure 1.

The same curve, plotted in accordance with the same indices, but not for the human eye but for various photographic light-sensitive emulsions, will have somewhat different forms (Figure 2).

All the light flux incident on the body (F_{inc}) can be divided into 3 parts (Figure 3): the light flux reflected from the body (F_r), the light flux absorbed by the body (F_a), and the light flux transmitted through the body (F_{tr}).

The ratio of the reflected flux to the incident flux is called the coefficient of reflection (ρ).

$$\rho = F_r / F_{inc}$$

The ratio of the absorbed flux to the incident flux is called the coefficient of absorption (α)

$$\alpha = \frac{F_a}{F_{inc}}$$

The ratio of the light flux transmitted through the body to the incident flux is called the coefficient of transmission or penetration (τ)

$$\tau = \frac{F_{tr}}{F_{inc}}$$

The part of the light flux that is reflected from the photographic plate (F_r) will not participate in the formation of the image. The part that passes through the body (F_{tr}) also does not participate in the formation of the image. Only the part that is absorbed by the body (F_a) participates in the formation of the image acting on the light sensitive silver compounds.

If both parts of the equation $F_{inc} = F_r + F_{tr} + F_a$ are divided by F_{inc} , we get

$$l = \frac{F_r}{F_{inc}} + \frac{F_a}{F_{inc}} + \frac{F_{tr}}{F_{inc}}$$

or, using the symbols adopted for the purpose, we get

$$l = \rho + \alpha + \tau.$$

The coefficients of transmission, reflection, and absorption are different for various materials, as can be seen from Table 1.

TABLE 1

Coefficients of

Material	Transmission (τ)	Reflection (ρ)	Absorption (α)
Transparent glass	0.8 - 0.85	0.08 - 0.1	0.1 - 0.05
Opal glass	0.35	0.25	0.40
Glass mirror	-	0.82 - 0.88	0.18 - 0.12
Iron covered with white enamel	-	0.65 - 0.75	0.35 - 0.25

For practical purposes we introduce the concept of the optical density (D) which is the decimal logarithm of the reciprocal of the coefficient of transmission (the transmission coefficient is also called transparency, and its reciprocal is called opaqueness).

Thus, the ability of the body to absorb the light incident on it can be characterized by the coefficient of absorption (α), transmission, or transparency (τ) and the optical density (D).

If we neglect the reflected light, which is not large in the case of materials used in photo-reproduction processes, one can write for the coefficients of absorption and transmission:

$$\tau = 1 - \alpha \quad \text{and} \quad \alpha = 1 - \tau$$

To understand the nature of the formation of the image in a photographic emulsion it is necessary to become briefly acquainted with the action of the absorbed light energy.

The quantum theory considers the propagation of light energy to be not in the form of a continuous stream, but in the form of individual batches called quanta. Here the value of a quantum (ϵ) is directly proportional to the radiation frequency. The higher the frequency of radiation, the larger the quantum of light energy. The mathematical value of the quantum is expressed by the equation

$$\epsilon = h\nu$$

where h is a constant coefficient, ν the radiation frequency, which is determined from the equation $\nu = c/\lambda$, where λ is the wavelength and c the velocity of propagation of light. One can therefore write

$$\epsilon = \frac{hc}{\lambda}$$

This, incidentally, explains why the maximum energy is displayed in photographic processes by the violet rays, and the minimum by the red rays: the violet rays are rays with the shortest wavelength (λ), and the red ones with the longest wavelength.

Many investigations have shown that the light energy can be absorbed only in integral quanta.

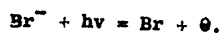
The formation of the photographic image is a very complicated process not yet fully understood. Schematically it can be represented in the following manner. Quanta of light energy, absorbed by the molecules (or by the atoms) of the substance, increase the reserve of their internal energy. A molecule, having absorbed a quantum and having increased the reserve of its internal energy, enters into a so-called active state, which lasts very shortly, and after which the

molecule starts decaying into atoms and liberating, for example, in the case of silver halide atoms, atoms of metallic silver and halide.

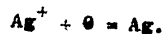
The nature and the physical-chemical character of these processes can be understood from the following data, obtained by many years of investigation of the process of formation of the photographic image.

The crystals of silver halide have a structure of a crystalline lattice of the ionic type (Figure 4). For silver bromide, for example, the Ag^+ and Br^- alternate in the sites of the crystalline lattice. As is known, positively charged ions are called cations, and negatively charged ones anions.

Many investigations have shown that in the case of a silver halide (for example AgBr), the light energy is absorbed by the anions. According to modern concepts, a quantum of energy, absorbed by the anion (for example Br^-) pairs off one of the electrons from the other orbit, which leaves its anion and converts it into a neutral atom. For the Br^- anion this can be expressed in the following manner:



The free electron (e) torn off the outer orbit of the anion, is joined to the cation, which at the same time becomes a neutral atom. For the Ag^+ cation this can be expressed in the following manner:



The sum total of this process can be written in the following manner:



Thus, a silver halide molecule in this case silver bromide was broken up into halide and silver atoms under the influence of light.

Since in practice we do not have individual molecules, but substances consisting of an uncounted number of molecules, the primary process is followed by further secondary physical-chemical transformations, during which the liberated atoms react with others and become interconnected into molecules of some other substance. Thus, the individual atoms of bromine (Br) or silver (Ag) can combine into bromine molecules or silver molecules, which evidently takes place



The formation of the image in light-sensitive emulsions can be represented by the following scheme. The light, incident on the photographic plate, is partly reflected, partly passes through the plate, and is partly absorbed. The absorbed part of the light energy acts on the molecules of a light-sensitive compound of silver (AgBr, AgI, or AgCl), bringing them into an active state. The active molecules break up and liberate atoms of silver. These atoms then combine and form molecules of metallic silver, which indeed make up the image. This action of light, is called the chemical action of light, since it causes chemical reactions in the light-sensitive material, while the process itself is called the photochemical process.

2. Development of the Latent Image

The visible image is not formed directly as a result of the action of the light. What is formed is the so-called latent image, which must be developed to convert it into a visible image.

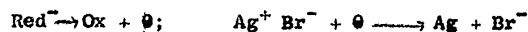
There are still no conclusive data available at present on what the latent image represents. However, investigations carried out in this field make it possible to establish, with a great degree

of probability, that the action of the light results in the formation of minute particles and metallic silver, which in further processes become the centers of light sensitivity and the centers of the development of the image.

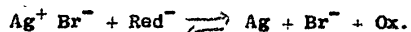
The process of the development of the latent image has still not been sufficiently studied. Modern theory considers it from the physical-chemical point of view, as a process of reducing the metallic silver in the crystals of silver halide, exposed to the action of light.

The reduction of metallic silver under the direct influence of the light results from its joining the electron, lost by the ion of bromine, iodine, or chlorine, as the result of the absorption of a quantum of energy by the latter. In the case of development this process occurs as a result of the silver ion becoming connected to the electron lost by the developer.

If we denote by Red^- the developing substance and by Ox its oxidized form, into which it changes after it delivers the electron to the silver ion, the developing process can be represented as



or summarily



The development of the latent image may be produced in 2 ways: chemical and physical. In chemical development the image is formed by the silver contained in the crystals of silver halide, which are inside the emulsion. In physical development the image is formed on the surface of the emulsion layer because of the silver which is introduced into the developing solution or directly on the light-sensitive surface, most frequently in the form of a solution of

silver nitrate (AgNO_3). Both in the chemical and in the physical development processes, the silver is reduced around the centers of the light sensitivity (or the development centers). In practice physical development is used in the wet-colloid method, which will be discussed in greater detail below, and the chemical development is used with all other photographic emulsions.

Development (chemical) consists of a gradual reduction of the silver halide crystals to metal, starting at the sensitivity centers and gradually including the entire crystals (or grains). This process is shown in Figures 5a, 5b, 6a, and 6b, which disclose photographs of exposed and developed grains (5), and also the subsequent stages of development (6).

The speed of development of the emulsion grains increases continuously, and this has led to the conclusion that the development process obeys the autocatalytic (autocatalytic -- self-accelerating) law. Here the particles of the silver that form the latent image play the role of catalysts. Naturally, as the silver halide crystal (emulsion grain) becomes developed, the amount of metallic silver (catalysts) increases, leading to an acceleration of the development process. Figure 7 shows a microphotograph of developed and undeveloped grains of silver halide.

There are many opinions concerning the mechanism of the development process. Some investigators believe that the metallic silver is reduced in the solution (developer), others believe that this process occurs directly in the crystal lattice.

The adherents of the first view believe that the silver halide enters into the solution from the emulsion grains to a small degree,

and thus the emulsion grains turn out to be surrounded by a saturated solution of AgBr. The ions of the developer, reducing the metallic silver around the emulsion grains, form a supersaturated solution of silver.

Wherever there are particles of the latent image, they act as crystallization centers and precipitate the metallic silver from the supersaturated solution and cause it to settle on the surface of the emulsion grains. Where there are no particles of the latent image, there is no crystallization, the silver remains in solution, and the grain is not developed.

Other investigators believe that the metallic silver is reduced on the surface of the silver halide crystals. Here it is assumed that the negatively-charged ions of the developer interact with the positively charged ions of the silver and where there are particles of the latent image, which act as catalysts, the silver bromide is reduced to metal. This process, occurring with increasing velocity due to the increase in the amount of catalyst, continues uninterruptedly until the silver halide crystal is fully developed.

We considered above the development in a crystal (emulsion grain) of silver halide. In practice one develops not individual crystals, but an emulsion layer, in which a large number of such crystals are distributed. The manner in which the development takes place is shown in Figure 8, where the white circles are silver halide crystals (the black dots indicate the presence of a latent image in the crystals), and the black circles are the developed silver halide crystals. The maximum amount of light acted on the first portion, and gradually diminished amounts acted on the second, third, and fourth portions. Figure 9 shows an enlarged photograph of a section through the emulsion layer on which the various stages of development are shown.

The formation of the sensitivity centers (of the latent image centers) and the reduction of silver to metal occur not only as a result of the action of light, but also during the process of the preparation of the photographic emulsion and its storage. In addition, the developer reduces silver in crystals with a latent image, as well as partially in crystals that have no latent-image particles. This indeed is the cause of fog. In good emulsions and with suitable developers, the fog is negligible, and this is accomplished by having the development (reduction) of the grains having no sensitivity centers. This is why full development of grains, subjected to the action of light, occurs long before the grains which have not been exposed to light can be developed on a noticeable scale.

Let us now become acquainted briefly with the nature of sensitization which plays an important role in photographic reproduction processes and is closely related to the action of light on the photographic emulsion.

Sensitization, in translation, denotes the acquisition of sensitivity. One distinguishes chemical sensitization and optical sensitization. The former increases the overall light sensitivity of the photographic emulsion, and the other expands the zone of its spectral sensitivity. Both these phenomena are closely related.

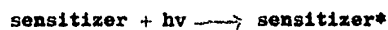
Of particular interest is optical sensitization, the nature of which will be briefly considered here.

If certain organic dyes are introduced into the photographic emulsion, the zone of its sensitivity is extended because of the zone of intrinsic absorption of these dyes. As a result of numerous

investigations, many dyes were discovered and synthesized with which it is possible to produce photographic layers sensitive not only to the entire visible spectrum, but also beyond its boundaries in the infrared region. Here is brief information on the increase in the spectral sensitivity of photographic emulsions [12].

Visible spectrum	400 - 700 m μ
Before 1875 -- glass optics	320 - 500 m μ
Before 1904 -- quartz optics, erythrosin (dye)	200 - 600 m μ
1904-1919 -- pinacyanol	200 - 720 m μ
1919-1925 -- cryptocyanin	200 - 820 m μ
1925-1931 -- neocyanin	200 - 900 m μ
1932-1934 -- xenocyanin	200 - 1100 m μ
1935 and later -- tetra and pentacarbocyanins	200 - 1300 m μ

According to modern concepts, the principle of action of the sensitizer can be represented as follows: the sensitizers are adsorbed on the surface of the silver halide crystals, i. e., the molecules of the sensitizer so to speak envelop the crystals. The molecule of the dye, having absorbed a quantum of energy in its intrinsic absorption zone, enters into an active state and transfers its excess energy to the silver halide crystal using the following scheme

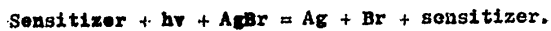


Furthermore, the $\text{sensitizer}^* + \text{Br}^- = \text{sensitizer} + \text{Br} + e$ and



* The star denotes that the molecule is in the active state.

Summarily one can express it as follows:



From the above it can be seen that the farther the light absorption of the sensitizer extends towards the long wave portion of the spectrum, the wider will be the spectral sensitivity of the photographic emulsion and the greater the variety of uses to which the photographic emulsion can be put.

Depending on the spectral sensitivity of the photographic emulsion, they can be subdivided into the following groups:

Unsensitized (ordinary), sensitivity of which does not go beyond $\lambda = 500 \text{ m}\mu$;

Orthochromatic, sensitized in the yellow-green portion of the spectrum ($\lambda = 600 \text{ m}\mu$);

Panchromatic, sensitized in the orange-red part of the spectrum ($\lambda = 700 \text{ m}\mu$). The spectral sensitivity of these emulsions covers the entire visible spectrum;

Infrared, sensitized in the zone with $\lambda > 700 \text{ m}\mu$.

The sensitization of photographic materials can be effected either by introducing the sensitizer into the photographic emulsion, or else by processing the photographic plate in a sensitizer solution. At the present time optical sensitization is effected in most cases by introducing the dye into the composition of the photographic emulsion.

CHAPTER II

SENSITOMETRY

For proper performance of the photographic process it is necessary to be able to determine the quantitative characteristics

under various conditions of performance of the process with various photographic emulsions. The branch of photography devoted to the study of the measurement of photographic properties of light-sensitive emulsions is called sensitometry, and the testing of photographic emulsions, performed to determine their photographic properties, is called sensitometric testing.

3. General Information

During sensitometric tests of photographic material the amount of illumination is varied in a definite manner. After exposing the material under standard conditions it is processed (developed, fixed, etc), and then the blackening formed in various portions of the material under the influence of various amounts of illumination is measured. The measurement data are used to plot a curve that expresses the dependence of the blackening on the amount of illumination. This curve, which makes it possible to determine many indices of the tested photographic emulsion and characterizing its properties, is called the characteristic curve. In practice the photographic emulsion is tested under various conditions of development and one obtains thereby not one, but several curves, characterizing the properties of the emulsion. Such curves are customarily called the family of characteristic curves.

From the information given in the preceding sections it follows that the blackening of the photographic plate will be greater, the more illumination is given to the photographic emulsion. The amount of illumination, called exposure, depends in turn on the illumination intensity (E) and on the time during which the layer is illuminated (t), and is given by the equation

$$H = Et,$$

where H is the quantity of illumination or exposure.

(In practice the term exposure is usually given not to the amount of illumination, but to the time during which the light acts on the photographic emulsion. Such a concept of exposure is wrong.)

If the illumination intensity E is measured in lux and the time t in seconds, then the amount of illumination (exposure) will be measured in lux-seconds. If the illumination intensity is measured in meter-candle units, the exposure will be measured in meter-candle-seconds units (CMS).

In sensitometric determination one determines not the blackening, but the optical density D , which is indicated, as the decimal logarithm of the opacity (O) and is determined by the equation

$$D = \log O = \log \frac{1}{T} = \log \frac{F_{inc}}{F_{tr}}$$

It follows from what was said above about sensitometric tests that the process consists of 2 stages. In the first stage the photographic emulsion is subjected to a definite exposure; the second stage measures the blackening (optical density). Instruments which expose the emulsion are called sensitometers, and those permitting measurement of the optical density are called densitometers.

The main portions of any sensitometer is the device for dispensing the illumination, called the exposure modulator, and a source of light.

It follows from the equation $H = Et$ that the exposure can be changed either by changing the amount of illumination, or by changing the time of illumination. Therefore there exist sensitometers with 2 types of modulators: with a time scale and with an illumination scale.

An example of a sensitometer having a modulator with a time scale is the Hurter and Driffield sensitometer (H and D system), in which the modulator is a disc with step-like cuts (Figure 10). Located between the source of light and the tested photographic layer, the disc is rotated rapidly and this permits various sections of the emulsion to receive a different exposure. A serious shortcoming of sensitometer of this type is that the photographic material is tested under conditions different from those in practice. Here we have a different illumination time with equal emulsion illumination intensity. In practice, to the contrary, the exposure time is constant and the emulsion experiences action at different illumination intensities from various parts of the photographed object.

In addition, detailed investigations have shown that, for example, at very low illumination intensity and at very long illumination time the blackening will be less than at correspondingly very large illumination intensities but very short exposure time, even though the 2 exposures are equal, i. e.,

$$H_1 = E_1 t_1 = H_2 = E_2 t_2 \text{ or } E_1 t_1 = E_2 t_2.$$

and this means that the same value of exposure may produce a different photographic effect, and if H is taken to mean the photographic effect, it can be expressed by the following equation:

$$H = Et^p.$$

The exponent p is a variable quantity and depends on the value of the illumination intensity. At certain average values of illumination intensity it is unity, at very large values it is greater than unity, and at very small values it is less than unity.

Sensitometers having modulators with an illumination-intensity scale are free of the shortcomings of the sensitometer in which the

modulators are based on a time scale. An example of such a sensitometer is the GOI (Government Optical Institute), sensitometer used in the USSR. In this sensitometer the entire tested photographic material is subjected to the action of light during the same time, but different parts receive different illumination intensities. The modulator in such sensitometers is an optical wedge, placed between the tested emulsion in the source of light. Since the mass of the optical wedge is made in the same gray color, the thicker the wedge, the less light passes through it, and consequently, the greater its optical density D .

Optical wedges can be of 2 types: continuous and stepped (Figure 11). The principal index characterizing the continuous optical wedge is its constant (K), which shows the increase in optical density for each centimeter of length of the wedge. If the initial optical density of the wedge is designated D_1 , the optical density D_2 of a point located at a distance l from the start of the wedge can be expressed from the equation

$$D_2 = D_1 + K l$$

The optical density of a stepped wedge varies from step to step by an amount K_s , which is also called the constant. If the density of the first step denotes D_1 , then for n steps the optical density D_n can be expressed from the equation

$$D_n = K_s (n - 1) + D_1$$

The GOI stepped-wedge sensitometer has a constant $K_s = 0.15$ and 21 steps.

Without going into a detailed description of the construction and of the operating scheme of various sensitometers and densitometers,

let us consider the nature of the sensitometric tests and their results, and also their possibilities and the limitations on the use of the results.

We spoke above of optical density, which can be understood from the following example. Assume we have several plates of gray color with a transparency $T = 1/10$, and consequently, with an opacity $O = 10$. The intensity of the light passing through such a plate is decreased by 10 times. If the plates are superimposed, each subsequent one passes $1/10$ of the light incident on it, and consequently, the second plate passes $1/100$ (0.01), the third $1/1,000$ (0.001), the fourth $1/10,000$ (0.0001) etc, or 0.1^2 , 0.1^3 , 0.1^4 , etc.

Thus, the opacity of the n 'th plate can be written in the form 10^n , corresponding to the total opacity of n plates (Table 2).

TABLE 2

Number of Plates	Intensity of light passing through	Transparency T	Opacity
1	0.1	0.1	10
2	0.01	0.1^2	10^2
3	0.001	0.1^3	10^3
4	0.0001	0.1^4	10^4
n	0.1^n	0.1^n	10^n

The optical density is the logarithm to the base 10 of the opacity, and consequently, for one plate it will be $D_1 = \log 10 = 1$, for 2 plates, $D_2 = \log 100 = 2$, for 3 plates $D_3 = \log 1,000 = 3$, for 4 plates $D_4 = \log 10,000 = 4$, etc, and for n plates it will equal $D_n = \log 10^n$. To know the optical density of the blackening, it is necessary to determine the intensities of the incident and transmitted

light through it and to calculate the difference in their logarithms. This principle is the basis for the operation of sensitometers, including the GOI system used in Russia (Gost 2817-45).

4. The Characteristic Curve

The optical densities of various fields of the sensitogram which are measured with the densitometer, can be used to plot a curve, using a graph (Figure 12), from which it is readily possible to determine the most important properties of a given light-sensitive emulsion for reproduction purposes. Such a curve, as already indicated, is called the characteristic curve.

To plot the characteristic curve it is necessary to lay off on the ordinate axis the values of the optical densities ($D = \log 0$) and to lay off on the abscissa axis the logarithm of the exposures ($\log H$). The resultant points are connected with a smooth curve, which is the characteristic curve (Figure 13). If the development times for different sensitograms of the same emulsion are varied within certain limits, one obtains not one but several curves, one for each development time, and these are called the family of characteristic curves (Figure 14).

The characteristic curve (Figure 13) can be broken up into several sections (a, b, c, d, e) corresponding to various properties of the given photographic emulsion within these limits. The section in which an increase of exposure does not increase noticeably the optical density of the blackening is called the section of photochemical induction (section ab of the curve). The section where increasing the exposure increases the optical density, but at a slower rate than the exposure (section bc) is called the underexposure region. The section (cd), which is a straight line, within which an increase in optical

density is proportional to the increase in exposure, is called the region of normal exposures. Finally, the last section of the characteristic curve (de), within which an increase in optical density again lags the increase in exposure, is called the underexposure region. There is still another portion, which is not shown on this characteristic curve, of solarization, within which increasing the exposure reduces the optical density of the blackening.

The regions of photochemical induction, underexposure, overexposure, and solarization cannot be used. The only working portion is the region of normal exposures, i. e., the part of the characteristic curve (cd), within which an increase in exposure results in a corresponding increase in the optical density, making it possible to control the photographic process. The underexposure and overexposure regions show the limits beyond which one cannot operate with a given photographic emulsion.

From the characteristic curve it is possible to determine the light sensitivity, the coefficient of contrast, the photographic latitude, the maximum (limiting) optical density, and the fog.

Light Sensitivity. The higher the light sensitivity of a photographic emulsion, the less the exposure required for the formation of the minimum of blackening. This is why the light sensitivity can be characterized by the amount of light necessary to produce a noticeable blackening of the emulsion. Usually the measure of light sensitivity is taken to be that exposure, which gives a practically usable blackening. In the GOI system such an exposure is an exposure leading to the blackening with an optical density D that exceeds the density of the fog (see below) by 0.2; this exposure is denoted H_D .

To determine the light sensitivity it is necessary to find on the characteristic curve a point with a density (D), exceeding the fog (which is also determined on the densitometer in the measurement of the fields of the sensitogram) by 0.2, and draw a perpendicular line from this point to determine (read) on the graph the value of the exposure (on the graph it will be denoted $\log H_D$, from which it is easy to find H_D).

In practice the sensitivity (S) is defined as a quantity that is the reciprocal of the exposure, expressing the light sensitivity in degrees GOI

$$S = \frac{1}{H_D}.$$

The light sensitivity of a photographic emulsion, the characteristic curve (III) of which is given in Figure 14, is 6° GOI.

Contrast Coefficient. The contrast coefficient, denoted γ , is of great importance in photography, particularly in reproduction photography. It is defined as the ratio of the increment in the optical densities of the blackening to the increment of the exposure causing this blackening and can be expressed by the equation

$$\frac{D_2 - D_1}{\log H_2 - \log H_1} \quad (a)$$

where D_1 is the optical density corresponding to exposure H_1 , and D_2 is the optical density corresponding to exposure H_2 .

The equation given above can be interpreted in the following manner. Assume that 2 different exposures H_1 and H_2 acted on 2 different parts of a tested photographic emulsion. These exposures caused blackening with optical density D_1 (in the first portion) and D_2 (in the second portion). Since high illumination (exposure) causes greater blackening owing to the larger amount of reduced silver, then D_2 will

be greater than D_1 if H_2 is greater than H_1 . Therefore the contrast coefficient γ , defined as the ratio of the increment in the optical density to the exposure increment causing the density, serves as an index characterizing the ability of the photographic emulsion to reproduce correctly the various brightnesses of the original on the negative (positive).

It can be seen from equation (a) that in those cases when the increment of optical density $D_2 - D_1$ equals the increment of exposure ($\log H_2 - \log H_1$), we have $\gamma = 1$, and the reproduction of the brightnesses of the original on the photographic emulsion will be correct. Such photographic emulsions are called normal. If however the increment of optical density does not correspond to the increment of exposure, the variation in the brightnesses of the original will not be correctly reproduced. Photographic emulsions with $\gamma > 1$ are called contrasty, and those with $\gamma < 1$ are called soft. Consequently, contrasty photographic emulsions are those in which small increments of exposure may cause a considerable increment of blackening, and soft ones are those in which a considerable increment of exposure causes a small increment of blackening.

For line reproduction, with which one deals principally in the publication of maps, the contrast coefficient is particularly important. When photographing the original of the map it is necessary to obtain on the negative the most transparent lines of the cartographic drawing against a background of maximum possible opacity (called "dense"). This is why in line reproduction, and in particular for the photography of originals of maps, one employs photographic emulsions with a maximum coefficient of contrast γ . This explains why the microcollodion method, which makes it possible to obtain

negatives with very high coefficients of contrast (4 or more) is still widely used for line photographic reproduction, particularly in the publication of maps, in spite of the tremendous successes attained in the preparation of dry silver-bromide photographic materials.

The contrast coefficient γ can be determined from the characteristic curve. Figure 15 shows the characteristic curve of photographic emulsion. Let us select on the line representing the normal exposure region points 1 and 2, corresponding to the optical densities D_1 and D_2 , and also to exposures H_1 and H_2 .

Instead of the equation

$$\gamma = \frac{D_2 - D_1}{\log H_2 - \log H_1}$$

one can write

$$\gamma = \frac{\text{segment 2-3}}{\text{segment 3-1}} = \tan \alpha$$

By determining the angle α it is possible to find the value of γ .

Photographic Latitude of the Emulsion. The term photographic latitude of a light-sensitive emulsion is usually used to determine those limiting (both maximum as well as minimum) exposures, within which the ratio of brightness of the original will be proportionally reproduced by the photographic image. In other words, the photographic latitude determines the straight-line portion of the characteristic curve, and in practice the photographic latitude is determined on the graph by the projection of this portion on the abscissa axis (Figure 16).

Assume that the brightness interval of the original is represented on the photographic image by points A and B of the characteristic curve, with optical densities D_A and D_B corresponding to exposures $\log$

H_A and $\log H_B$. Let us now assume that the photographic emulsion receives exposures $\log H'_A$ and $\log H'_B$, corresponding to points A' and B' of the characteristic curve with optical densities D'_A and D'_B . If $D'_B - D'_A = D_B - D_A$, and correspondingly $\log H'_B - \log H'_A = \log H_B - \log H_A$, this means that in both cases the brightness range of the original is reproduced on the image identically. Consequently, in spite of the fact that $\log H_A \neq \log H'_A$ and $\log H_B \neq \log H'_B$, one can insure correct reproduction of the relative brightnesses of the original, provided the exposure does not go outside the limits of the straight-line section of the characteristic curve. It follows from this that errors in exposure (within the straight-line section of the curve) cannot affect the correctness of the reproduction of the relative brightnesses of the original.

The photographic latitude is of particular importance to map-publishing in the photography of halftone originals (for example, wash drawings of the relief), when one photographs not a screen but a halftone negative. In case of line reproduction the photographic latitude has no great significance.

Maximum Density. As already seen, the optical density given by some photographic emulsion cannot be higher than a certain value (the overexposure region on the characteristic curve), after which increasing the exposure causes a reduction in the density (solarization region). This value of the optical density is denoted by $D_{\max}$ and is called the maximum optical density of a given photographic emulsion. On the graph the maximum optical density is determined by the ordinate of the highest point of the characteristic curve. For the emulsion the characteristic curve of which is given in Figure 14, $D_{\max} > 3$.

Fog and its Density. If photographic emulsion is developed even without exposure, after a certain time there will appear in it a certain blackening, which is called fog. The fog affects the quality of the negative; therefore, if it cannot be avoided entirely, the tendency is to make its optical density as small as possible. Photographic material with optical density of fog exceeding 0.2 is not suitable for work.

In map publishing the reproduction work is always carried out under conditions of constant standard illumination, making it possible to choose for any photographic material the best exposure with sufficient accuracy. Therefore, as indicated, the photographic latitude of the emulsion cannot play a substantial role in the choice of material. Nor is the maximum density of the layer of great significance, for in the reproduction of the originals of the map it is always possible to increase the optical density of the background of the negative by intensification, about which detailed information will be given below. In map publishing the photographic materials must not have high light sensitivity. To the contrary, it is desirable to operate with materials of relatively low sensitivity, for in this case, owing to the more or less prolonged exposure, lasting for several minutes, the entire process can be performed more easily.

Thus, two indices are of importance in the choice of photographic material, the contrast coefficient and the fog.

Map publishers must see to it that the contrast coefficient γ be not less than 3, and that the fog density D_0 be at a minimum (0.02-0.03).

CHAPTER III

EQUIPMENT AND MATERIALS FOR THE PHOTOGRAPHIC REPRODUCTION PROCESS

5. Photographic Reproduction Apparatus

A large number of various constructions of photographic cameras are used for photographic reproduction processes. Cartographic practice makes particularly extensive use of the horizontal photographic camera (Figure 17), and in recent years also of suspended cameras (Figure 18), different from the horizontal ones in that their base (stand) is attached to the ceiling or is mounted on special supports, while in horizontal cameras they are mounted on the floor of the photographic room. There is an increasing use of 2-room cameras (Figure 19), in which the screen is located in an illuminated room, and all the remaining equipment is in a darkened room, and as a result it becomes unnecessary to employ a special camera, for the role of the latter is played by the dark room. In the predominant majority of cases one employs, as mentioned, horizontal cameras.

Screen. If it is not required that great accuracy be maintained in holding to the dimensions of the image on the photographic plate, the screen may be made of an even wooden board. Inasmuch as in the photography of a publication map original it is necessary to retain as accurately as possible the dimensions of the cartographic drawing, the screen of modern apparatus is made pneumatic. In a pneumatic screen the original is placed between a rubberized cloth and plate glass, a pump is used to pump out the air so that the outside air presses against the rubber cloth which in turn presses the original, which becomes flat, against the glass to insure maximum accuracy of dimensions in the photograph.

The camera serves to protect the light-sensitive plate during the exposure time against the action of all light rays except those that are reflected from the original, pass through the objective, and form the photographic image. The camera has a forward wall, on which the objective is mounted, and a rear wall, in which the cassette with the light-sensitive plate is placed during the exposure or in which a ground glass is placed during the focusing of the camera. The front and rear walls of the camera are connected by a movable bellows, which insulates the internal part of the camera and prevents light from penetrating there. The movable bellows make it possible to bring the forward and rear walls of the camera close together or move them apart when photographing originals with various reductions or magnifications.

The base (stand) is a metallic support, on which are placed the screen of the camera, and along which the camera is moved closer to the screen or away from it. The stand is always placed on equalizers, so that the camera and the screen can always retain the correct mutual position during the time of the exposure.

The cassette serves so to speak as a case for protection of the photographic plate against the action of light when it is transported or after the exposure, and holds the photographic plate during the exposure in a rigidly fixed position.

In addition to the photographic camera with the cassettes, certain optical instruments (objectives, prisms, etc) are required for the photography, and these will be discussed in Section 6. Sources of light are also required (Section 7).

Checking the Camera. Prior to the photography it is necessary

to check correctly the photographic camera and to adjust it. It is also necessary to eliminate the cassette difference, if it exists, and to insure perpendicularity of the planes of the screen and of the ground glass to the principal optical axis of the objective, and consequently to insure a parallel relationship between the 2.

The cassette difference is due to the fact that the plane of the ground glass, on which the image is measured, does not coincide with the plane of the photographic emulsion, on which this image is produced. The cassette difference leads to a discrepancy between the actual dimensions of the image on the negative and the dimensions of the cartographic drawing as measured on the ground glass. Figure 20 illustrates schematically the cassette difference.

The key to this drawing is: 1 -- objective; 2 -- plane of screen with the object being photographed (ab); 3 -- plane of ground glass with image projected on it (AB); 4 -- plane of photographic (light-sensitive) emulsion with projection of the image (A_1B_1). Figures 20a and 20c show situations where the plane of the ground glass and that of the photographic emulsions are parallel to each other, while Figures 20b and 20d correspond to a case when the 2 are not parallel.

As can be seen from the drawing, the cassette difference causes the image obtained on the negative to be either larger or smaller than the specified value.

The deviation between the quantity A_1B_1 and the specified value AB depends on the magnitude of the cassette difference, i. e., on the difference between the point on the ground glass (3) and that on the photographic emulsion (4), and on the position of the latter. Calculations

made for the simplest case (Figure 21) show that the dimensions on the negative may become considerably distorted as a result of the cassette difference.

The relationship between the errors in the dimensions of the negative and the cassette difference can be expressed approximately by the following equation

$$p = 2k \tan \phi$$

where p is the difference between sections A_1B_1 and AB ($p = A_1B_1 - AB$) and represents the error in the dimensions of the negative, k -- the cassette difference, and ϕ -- the angle formed between the outer rays aA and bB and the principal optical axis of the objective.

Using this equation to calculate the value of p for various values of k and ϕ , we obtain the errors in the dimensions of the image on the negative resulting from the influence of the holder difference (Table 3).

This table shows that a cassette difference of only 0.5 mm may lead to a substantial error in the dimensions of the image on the negative, and that the error in the linear dimensions of the image increases with the size of the originals. It also follows from the table that the influence of the cassette difference diminishes with the focal length of the lens used to produce the image.

The effect of the cassette difference is not restricted only to deviation in the dimensions of the image from the specified values, for since the plane of the photographic image does not agree with the plane of the ground glass on which the focusing was done, the image produced on the negative in the case of a cassette difference is not sharp.

TABLE 3

Errors in dimensions of image at following cassette difference:

Focal Distance of Objective (mm)	Length of Side of Original (mm)	0.5	1.0	1.5	2.0	2.5	3.0
450	400	0.44	0.88	1.32	1.76	2.22	2.66
	600	0.66	1.34	2.00	2.66	3.32	4.00
600	400	0.34	0.66	1.00	1.34	1.66	2.00
	600	0.50	1.00	1.75	2.00	2.50	3.00
	800	0.66	1.34	2.00	2.66	3.32	4.00
900	400	0.22	0.44	0.66	0.88	1.10	1.34
	600	0.34	0.66	1.00	1.32	1.66	2.00
	800	0.44	0.88	0.67	1.76	2.22	2.66
	1,000	0.56	1.12	1.66	2.22	2.78	3.22

TABLE 3

Errors in dimensions of image at following cassette difference:

Focal Distance of Objective (mm)	Length of Side of Original (mm)	0.5	1.0	1.5	2.0	2.5	3.0
450	400	0.44	0.88	1.32	1.76	2.22	2.66
	600	0.66	1.34	2.00	2.66	3.32	4.00
600	400	0.34	0.66	1.00	1.34	1.66	2.00
	600	0.50	1.00	1.75	2.00	2.50	3.00
	800	0.66	1.34	2.00	2.66	3.32	4.00
900	400	0.22	0.44	0.66	0.88	1.10	1.34
	600	0.34	0.66	1.00	1.32	1.66	2.00
	800	0.44	0.88	0.67	1.76	2.22	2.66
	1,000	0.56	1.12	1.66	2.22	2.78	3.22

It follows from the above that the cassette difference must be eliminated before the beginning of the photographic work. Methods of checking the presence of cassette difference and methods of eliminating it are found in the technological instruction on photographic work [3].

A cassette difference may occur only if a cassette is used. If one works without a cassette (for example, with a 2-room camera), there is no cassette difference, since the photographic plate is inserted every time in place of the ground glass and consequently the plane of the photographic layer always coincides with the plane of the ground glass.

The condition that the plane of the screen and the plane of the ground glass must be perpendicular to the optical axis of the lens, i. e., that they must be parallel to each other, must also be observed in order to retain the correspondence between the specified and actual dimensions of the image.

Figure 22 shows an example in which the plane of the screen is not perpendicular to the optical axis of the lens but is inclined to it. A straight line ab , bisected by point o , is drawn on the screen (2). On the ground glass (3) it is represented by the line AB , which is bisected by the point o_1 . If the screen is inclined to the optical axis of the lens, the straight line ab will occupy position a_1b_1 and will produce on the ground glass an image A_1B_1 . As can be seen from the drawing, line a_1b_1 is bisected by the point o , while the lines A_1B_1 is divided by point o_1 into 2 unequal parts.

Thus, with proper position of the screen and of the ground glass with respect to the optical axis of the lens and with respect to each other, we have the following conditions:

(1) Triangle alb is similar to triangle A_1B_1 ;

$$(2) \quad ao = ob; \quad A_1O_1 = O_1B_1; \quad \frac{ao}{A_1O_1} = \frac{ob}{O_1B_1}$$

If this condition is violated, for example, in the case when the screen is not perpendicular to the principal optical axis of the lens, we obtain the following conditions:

(1) Triangle a_1lb_1 is not similar to triangle A_1B_1

$$(2) \quad a_1o = ob; \quad A_1O_1 \neq O_1B_1; \quad \frac{a_1o}{A_1O_1} \neq \frac{ob_1}{O_1B_1}$$

In other words, we obtain an uneven deformation of the linear dimensions of the image. In section A_1O_1 the image is magnified, and in section O_1B_1 , to the contrary, it is reduced.

We considered a case when only the screen is inclined to the optical axis, while the plane of the ground glass remains perpendicular. One can easily see that a similar result will be obtained if the screen is perpendicular to the optical axis and the ground glass is inclined. If both planes (screen and ground glass) are inclined to the optical axis of the lens an analogous construction, although more complicated, is obtained.

The errors in the linear dimensions of the image when the planes of the ground glass and of the screen are not perpendicular to the principal optical axis of the lens may reach considerable values and in case of reproduction of originals with very complicated or fine drawings they frequently result in spoilage. They cause particularly much trouble in the preparation of originals of multi-sheet or nomenclature maps which must be carefully matched at the places where the various sheets are pasted together. Difficulties arise also when dimensions are determined in the reproduction of topographic maps, which as is known are used to perform measurements, calculations, and various types of design.

Sometimes the screen is intentionally not placed perpendicular in an attempt, so to speak, to bring an already deformed image to its theoretical dimensions. In some cases this may be effective to some extent. As a rule, however, such a measure must not be used in manufacture. It is best to adopt measures whereby correct dimensions of the originals are retained, rather than to have to eliminate errors in the photography.

Measures for checking whether the planes of the screen and of the ground glass are perpendicular to the optical axis of the objective are indicated in the Technological Instructions for Photographic Work. One must become strongly aware of the fact that elimination of the cassette difference and insurance of the perpendicularity of the screen and ground glass planes to the main optical axis of the lens and, thereby, the insurance of a parallel relationship between the 2 are essential conditions without which one cannot start any photographic work.

6. Optical Equipment for Reproduction Photography

To be able to photograph an original of a map, a photographic camera alone is not enough; one must have also objectives and prisms or reversing mirrors.

Objective. The objective serves to project on the ground glass an image of the drawing located on the original. After the ground glass is replaced by the photographic plate, the image projected by the objective will act correspondingly on the light-sensitive emulsion.

The simplest objective is a doubly-convex lens. Rays of light travelling from a remote object and incident on its surface as a

parallel beam, are refracted by the glass of the objective and are directed to a single point (Figure 23).

The point at which all the rays meet (f) is called the principal focus of the objective; the distance from the optical center of the objective (o) to the point f is called the principal focal distance (F).

In addition to the principal focal distance, usually marked on the mount of the objective, the objective always has so-called conjugate foci and conjugate focal distances, which are formed when images close to the objective are projected by the objective (Figure 24).

Depending on their radius of curvature, lenses can be either short-focus or long-focus. The magnitude of the focal distance of the objective is of great importance to the map publisher. For map publishing and particularly for editing-composing and form work it is necessary to have a set of long-focus and short-focus objectives.

The ordinary lens has shortcomings, because of which it cannot be used as a reproduction objective for cartographic purposes. The principal shortcomings are spherical aberration, coma, chromatic aberration, distortion, astigmatism, and several others.

Spherical Aberration. Spherical aberration manifests itself in the fact that the rays of light passing through the lens are refracted in various portions of the lens at different angles. The lens can be represented as a group of individual prisms, each characterized by its own refraction angle (Figure 25). In this case, the greater the distance from the center of the lens to its edges, the greater the refracting angle. Consequently, the farther the light ray passes away from the center of the lens, the stronger it becomes

refracted (the larger the angle). This is why rays passing at the edges of the lens will become focused closer to the lens, and rays passing near its center will become focused farther away. This causes the image to become blurred or washed out. In the publication of maps it is necessary to obtain in the negative and in the printed form a clear image of the cartographic drawing and spherical aberration cannot be tolerated at all.

Comma. When rays of light pass at an angle to the optical axis, the image of the point assumes a form of an asymmetrical spot.

Objectives from which spherical aberration and comma have been eliminated are called aplanatic.

Chromatic Aberration. Chromatic aberration is caused by the fact that rays with different wavelengths are refracted in different manners and form foci at different points of the optical axis, the focus of the blue lights being closer to the lens and that of the red light farther away (Figure 27). Chromatic aberration also produces a blurred image. Chromatic aberration is particularly harmful in the photography of originals drawn in several different colors. The objectives from which chromatic aberration is eliminated are called apochromatic.

Astigmatism leads to a condition whereby in one position of the ground glass only the horizontal lines of the drawing are sharp, and in another position only the vertical lines are sharp. This is caused by the fact that the rays of light incident on the lens at an angle to the optical axis produce when emerging from the lens not one, but 2 foci, one for the horizontal lines (or elements of the drawing) and the other for the vertical lines (Figure 28). Objectives from which astigmatism is eliminated are called anastigmats.

At the present time the name "anastigmat" has been extended to include all objectives from which not only astigmatism, but all other aberrations have been eliminated.

Distortion manifests itself in straight lines being projected by the lens as curved ones. Depending on where the diaphragm is located, the lines become either concave or convex. If the diaphragm is located in front of the objective, the lines become concave, but if it is back of the objective, they become convex. This shortcoming is well corrected in symmetrical systems, in which the diaphragm is located in the middle.

Curvature of Field of the Image. This defect is caused by the fact that the lens, representing a spherical surface, has a focal surface that is spherical. The curvature of the field of the image manifests itself in the fact that a sharp image of points located in various places of the drawing is obtained at different positions of the ground glass (Figure 30).

Modern reproduction objectives used for map publishing are free of these defects.

Prism or Reversing Mirror. In the publishing of maps it is sometimes necessary to produce in the negative not a mirror image, as is usually projected by its reproduction lens, but a direct one. For example, in the preparation of printed forms by positive copying or in the case when only one negative is photographed directly and selective coloring is used to obtain the required number of maps by contact means. A prism or a reversing mirror is used for this purpose.

A mirror or a prism, which inverts the image already inverted by the objective, is placed between the objective and the ground glass.

The action of the reversing mirror on the prism is seen from Figures 31 and 32. Rays reflected by the original, entering through the objective and incident on the mirror or prism, are reflected from it. Since the mirror (or prism) is mounted at an angle of 45° to the plane of the screen and to the picture, which during the photography with prism are perpendicular to each other, the rays reflected from the mirror or from the prism fall on the light sensitive emulsion and produce a mirror image. Thus, a direct image of what is drawn on the publishing original will be formed on the negative.

The basic data characterizing the reproduction objective are the focal distance, the relative aperture and the luminosity, the field and angle of view and of the image, and the resolution.

Focal Distance. When choosing an objective one must first pay attention to the focal distance, on which the scale of the image depends. The greater the focal distance, the greater the image that can be produced. Consequently, the greater the image required, the longer the focus of the objective must be.

Maps are usually drawn on sheets, the size of which fluctuate from 60-70 to 110-130 cm in length. One naturally employs objectives with large focal distances. Short-focus objectives are necessary only in those cases, when originals or cartographic materials with a large reduction (5-6 times or more) are photographed. To photograph at a reduction of, say, 10 times with an objective focal distance of 120 cm, one would need a camera approximately 15 m long, while at $F = 45$ cm one would need a camera only 5.5-6 m long.

In cartographic enterprises equipped with 80 x 80 cm cameras it is advisable to have a set of objectives with focal distances of

90, 60, 45, 30, and 15 (or 18) cm. If a 100 x 100 or 120 x 120 cm camera is available, one needs in addition an objective with a focal distance of 120 cm.

The relative aperture of an objective is the ratio of the effective aperture to the focal distance. If the value of the effective aperture of the objective is denoted by d , then the relative aperture is expressed by the ratio d/F or $1/F:d$. This ratio is the one usually written down on the mount of the objective in the form 1:4.5; 1:6.3; 1:9; 1:12.5; 1:18; 1:36 etc. Sometimes for economy in space only the denominator of these ratios is marked on the mount. The relative aperture of the objective can be varied with the aid of a diaphragm, increasing or decreasing the effective aperture of the objective.

The value of the relative aperture characterizes the brightness of the resultant optical image, which is proportional to the square of the relative aperture (d^2/F^2 , using the above symbols). If, for example, the relative aperture of one objective is 1:6.3, and that of the other is 1:9, the image produced by the first objective will be brighter than the image produced by the second objective by $(9/6.3)^2 = 2.041$ or, rounding off, by a factor of 2.

The ratio d^2/F^2 or $(1/F:d)^2$ is called the aperture ratio. It must be remembered that the numbers marked on the mounts of the objective are not the aperture ratios, as many workers in reproduction photography incorrectly believe, but the relative apertures, the values of which are so chosen so that when the change is made from one to the other the value of the exposure is increased by a factor of 2. It must also be recognized that the values of the

relative apertures marked on the mount of the objective are referred to the value of the principal focal distance. If the original of any map is photographed with a large magnification, the conjugate focus is farther away than the principal focus, and the brightness of the image will diminish with the increasing coefficient of magnification.

The brightness of the image is not uniform also owing to the nonuniformity of the distribution of light in the focal plane. The illumination intensity of the image diminishes from the center towards the edge in proportion to the fourth power of the cosine of the angle between the extreme rays of the given image and the central ray. If in addition we take into account the effect of the so-called vignetting, then the mathematical expression for the illumination intensity at various parts of the image can be expressed by the equation

$$E_{\omega} = E_0 \cos^4 \omega k_B$$

where E_{ω} is the illumination intensity at any point of the image at some distance away from the center; E_0 is the illumination intensity at the center of the image; ω the angle between the ray incident at a given point and the central ray, which is the principal optical axis; and k_B is the coefficient of vignetting.

If we assume $E_0 = 1$, and discard the effect of k_B , the illumination intensity at any point of the image, expressed in terms of the illumination intensity at its center, can be given by the equation

$$E_{\omega} = \cos^4 \omega$$

If we now use this equation to calculate the value of the illumination intensity for various values of ω , depending in turn

TABLE 4

Scale of photograph	Camera extension (cm)	Distance of point from center of image (cm)	E_{ω}
1	2	3	4
0.5	135	10	1.0
		20	1.0
		30	0.9
		40	0.8
1.0	180	10	1.0
		20	1.0
		30	1.0
		40	0.9
1.5	225	10	1.0
		20	1.0
		30	1.0
		40	1.0
2.0	270	10	1.0
		20	1.0
		30	1.0
		40	1.0
0.5	90	10	1.0
		20	0.9
		30	0.8
		40	0.7
1.0	120	10	1.0
		20	1.0
		30	0.9
		40	0.8
1.5	150	10	1.0
		20	1.0
		30	1.0
		40	0.9
2	180	10	1.0
		20	1.0
		30	1.0
		40	0.9

on the dimensions of the original and on the extension of the camera, it is possible to obtain an idea of the drop in illumination intensity at the edges of the image from data given in Table 4.

It can be seen from the table that when working with an objective

with a focal distance $F = 60$ cm and when photographing in natural size, the illumination intensity at the edges of an 80×80 cm negative diminishes by 20%, and in the case of photography with half-size reduction -- even to 30%. Such a change in the brightness of the image must be taken into account. Many defects in the quality of the negative result from the fact that the photographers do not take into account the drop of illumination intensity towards the edges.

To eliminate the effects of uneven brightness of the image in the photography of originals of maps, particularly if their sizes exceed 50×60 cm, it is necessary to increase the illumination at their edges.

Angle of View and Angle of Image. For practical purposes one is interested usually not in the angle of view or the image, but in the field of view and particularly in the field of the image. The light passing through the objective is projected on the ground glass in the form of a bright circle. This circle is called the field of view of the image. The square inscribed in the field of view is called the field of the image.

The following relationship exists between the angle of view of the objective (or the field of view) and its focal distance: the longer the focus of the objective, the smaller its angle of view, and vice versa. Therefore in long-focus reproduction objectives used in the publication of maps (60, 90, 120 cm) the angle of view (the field of the image) does not exceed 40 deg. Starting with these considerations, one can calculate what objective must be used for each individual case of photography. In this case one can use the following equation

$$F = \frac{rn \cot \frac{\alpha}{2}}{n + 1}$$

where F is the focal distance of the objective, r is the distance from the center of the image to its edge, which in the limit equals half the diagonal of the original, α half the angle of view of the objective, and n the scale of the photograph.

Assuming the angle of view to be 40 degrees one can calculate the focal distance of the objective that must be used for various values of r and n (Table 5). In this case the equation assumes the following form:

$$F_{cm} = \frac{2.75 rn}{n + 1}$$

From the table given one can make the following conclusions:

(1) Short-focus objectives are needed for photography with large reduction.

(2) For photography in natural size or nearly natural size it is enough to employ an objective with a focal distance that equals the length of the side of the original (if it is square) or the length of its larger side if it is not square.

(3) For photography with magnification by a factor of 2 or more it is necessary to employ objectives with focal distances not less than the length of the diagonal of the original.

These considerations must always be borne in mind in the choice of objectives for a definite shot.

The resolving power of the objective is also of great significance in reproduction photography. By resolving power of an objective is meant the limiting possibility of its reproducing a very small detail of the drawing. It is expressed as the number of separately distinguishable lines per mm. The resolving power of modern objectives (R) can be determined from the following equation

$$R = \frac{1690}{k}$$

where k is the denominator of the relative aperture.

TABLE 5

Diagonal of original (cm)	Scale of photograph							
	0.1	0.3	0.5	0.8	1.0	1.3	1.5	2.0
20	2.5	6.3	9.2	12.2	13.8	15.5	16.5	18.3
40	5.0	12.7	18.3	24.4	27.5	31.1	33.0	36.7
60	7.0	19.0	27.5	36.7	41.2	46.6	49.5	55.0
80	9.1	25.4	36.7	48.9	55.0	62.2	66.0	73.7
100	11.6	31.7	45.8	61.1	68.8	77.7	82.5	90.0
120	14.1	38.1	54.3	73.3	82.5	93.2	99.0	110.0

Thus, for an objective with a relative aperture 1:9 the resolving power $R = 1690/9 = 188$ lines per mm.

7. Sources of Light

The choice of sources of light in photomechanical processes is of great practical significance. Sources of light should satisfy the following requirements:

- (1) ensure the necessary illumination of the photographed object;
- (2) the spectral composition of the light must have the highest activity for the photographic materials employed.

The light best satisfying these requirements is scattered sunlight, but in practice it is not convenient to use it because it varies with the weather, time of the year, and time of the day. Therefore one employs for all photomechanical processes various electric sources of light.

The most frequently employed are:

- (1) Incandescent lamps.
- (2) Arc lamps.
- (3) Various gas lamps.
- (4) Fluorescent lamps.

Incandescent lamps. In the basic map-publishing processes these lamps are hardly ever used because they radiate, principally, the yellow-red portion of the spectrum (yellow, orange, and red rays) and to very small extent the short-wave portion of the spectrum, and the light flux from even very strong incandescent lamps is too low for ordinary photographic materials, used in publishing. The use of such lamps as light sources would have led to an increased exposure

time in the photography, and this is not acceptable economically and technically, particularly in the wet-colloid method.

It is even less advisable to employ incandescent lamps with glass bulbs colored blue, even though they do give the best composition of light, in view of the large absorption of light by the colored glass.

Incandescent lamps are used in individual photomechanical processes for the most light-sensitive materials, for example, in contact printing processes with silver bromide photographic materials (film and papers).

Arc lamps have up to recently been almost the sole source of light in all photo-reproduction and photo-copying processes.

Arc lamps are based on the use of the Petrov arc as a source of light.

The electrodes of the Petrov arc are heated to a temperature of 3,000-4,000° and give light with the best spectral composition. Such lamps have a light with intensity of 900-3,000 candles, and their light emission amounts to 27 lumen/watt, which is considerably higher than even the most powerful incandescent lamps.

The Petrov arc represents the following phenomenon. Two conductors are connected, an electric current is passed through them, and the conductors are then separated. If the potential difference across the electrodes is low, a spark is produced the instant they are separated. But if the potential difference is high enough, it is possible to separate the electrodes to a definite limit and obtain not a spark, but a continuous glowing arc. The electric current is carried in this case by incandescent gases surrounding the electrodes.

In d-c arc lamps (Figure 33), one electrode is always negative and the ions of the gas carry the electricity from this electrode to the second electrode, which is positive. A slight crater (cup) is formed on the positive electrode, which is heated to 4,000° C and gives the maximum amount of light (up to 85%). The negative electrode, heated to a temperature of approximately 3,000° C, yields 10% of the total amount of light; 5% is radiated by the incandescent gases located between the electrodes, i.e., by the arc itself. In a-c arc lamps the poles interchange places continuously and the electrodes radiate an equal amount of light each, giving jointly 95% of the total amount of light (47.5% each); the share of the arc remains the same, 5%.

With all their advantages, arc lamps also have certain substantial shortcomings. They require careful maintenance; it is necessary to watch the carbons of such lamps; slight deviations of the diameter of the carbon causes them to break down in operation; they liberate during operation gases which are harmful to the health and produce much dust; pieces of carbon, falling on the glass of the copying frame, spoil it; finally, they consume a large amount of electricity.

All these shortcomings make it necessary to search for other sources of light, which, having the advantages of arc lamps, would be free of their shortcomings. Daylight bulbs and quartz lamps were suggested as sources of light and turned out to be suitable only for photographic reproduction work. In photocopying work with chrome-treated colloids these fixtures are less effective than arc lamps.

The question of possible application of quartz lamps and various

daylight lamps as universal sources of light for photomechanical work is still not sufficiently studied at the present time and the principal, most reliable fixture is still the arc lamp.

8. Light-Sensitive Materials Used in Photographic Processes

The light-sensitive materials used for various photomechanical processes are those chemical compounds which make it possible to fix the image obtained with the aid of light. These include halide compounds of silver and certain compounds of iron.

1. Halide compounds of silver are unstable in the presence of light. By exposing them to the action of light and treating them properly, one can recover the silver in metallic form.

Halides (halogens) are a group of chemical elements including chlorine (Cl), iodine (I), bromine (Br) and Fluorine (F). Only chlorine, iodine, and silver compounds are used. Fluorine silver compounds are not light sensitive.

Of the 3 compounds employed in photography, the most sensitive to light are the bromides; iodine compounds of silver are less light sensitive, and chlorine compounds have the lowest light sensitivity.

2. Certain Iron Compounds. It is known that certain iron compounds (for example, citric-acid ammonia compounds) are capable of producing under the influence of light an azure or a blue precipitate that is insoluble in water and this can form an image. By special treatment one can obtain not only a blue, but also a brown image.

Dry photographic light-sensitive materials represent photographic emulsions, coated on some base. The base used in most cases is glass, various transparent films, and paper. The materials in which

glass serves as a base are called photographic plates; if the base is paper, they are called photographic papers. Thus, the base determines the type of the photographic material. Its properties are determined by the properties of the emulsion layer, which can be ordinary unsensitized, orthochromatic, panchromatic, etc.

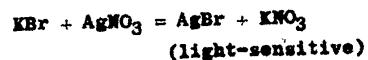
The emulsion layer consists of gelatine, in which are distributed grains (crystals) of halide (halogen) silver, having dimensions from fractions of a micron to 5 microns.

In addition to gelatine and silver halide, which are basic components, the emulsion contains sensitizers (dyes) to produce the necessary light sensitivity, phenol to preserve it, etc. However, these additions do not exceed 1% of the total contents of the emulsion.

Emulsions are poured on the base in very thin layers. The thickness of a dry emulsion layer amounts to:

low-sensitivity plates	0.012 - 0.0016 mm
negative plates	0.019 - 0.024 mm
positive films	0.010 - 0.012 mm
negative films	0.014 - 0.018 mm
photographic papers	0.006 - 0.012 mm

The process of manufacturing the photographic emulsion can be represented as follows. A solution of silver nitrate (AgNO_3) is added to a solution of gelatine to which bromide or other halide salts (for example, potassium bromide KBr , potassium iodide KI). These substances interact in a double-exchange (double-substitution) reaction to form silver halide grains



Depending on the methods used to perform this operation, various sizes of crystals of silver halide (in this case bromide) may be formed. The following relationship exists between the size of the grain and the sensitivity: the larger the grains of the silver halide, the higher the light sensitivity of the emulsion.

The formed grains of the silver halide remain in the layer of the gelatin and together with it make up the emulsion (strictly speaking, a suspension is formed). This process is called emulsification.

But the emulsion obtained from the emulsification process is still not ready to be coated on the base. Before it becomes finally ready, it passes through stages of the so-called maturation. During the first maturation there occurs the solution of the minutest crystals and the resultant growth of larger crystals. In the second maturation the sensitivity of the emulsion increases. The nature of the second maturation is such that a complicated interaction of the gelatin with the Ag^+ ions causes impregnation of particles of metallic silver into the crystalline lattice on the surface of the silver-halide grains. These particles later become centers of the light sensitivity, for particles of the latent image will be formed around them. Between the first and second maturation, the emulsion is washed.

The emulsion, after passing the stages of the first and second maturation, is ready for the manufacture of photographic plates, photographic films, or photographic papers. After the second maturation and before pouring on the base one introduces into the emulsion the remaining additives: sensitizers, preservatives, etc.

Before coating the emulsion on the base, a priming layer is

coated on the base, i.e., an intermediate layer, which is necessary to fasten the emulsion layer on the glass, celluloid, or to another transparent base; when coating the emulsion layer on paper, the primer protects the emulsion from the harmful effect of the base.

The grains of the silver halides are distributed in the emulsion layer in several rows (strata). For example, a high-sensitivity emulsion layer of photographic plate 0.02 mm thick contains from 20 to 40 rows of such grains.

The manufacture of photographic films differs little in principle from the manufacture of photographic plates. Since photo-technical films are rather widely used in the publication of maps, let us consider their assortment, with the basic features of each grade.

Photographic films issued for polygraphic works are called photo-technical (PT). Along with this designation, they are marked with an index, consisting of 2 digits, the first characterizing the contrast of the emulsion, namely: 1 (half tone soft), 2 (line normal), and 3 (line contrast). The second digit characterizes the optical sensitivity of the emulsion and may be either 0 (unsensitized), 1 (iso-orthochromatic), and 2 (iso-panchromatic).

Thus, the index, consisting of 2 numbers, makes it possible to determine the features of the photographic film and its application limits. Thus, for example, "PT-32" denotes that this is a line contrast iso-panchromatic film. The phototechnical (reproduction) films produced by the industry are the following:

FT-10	Half tone	Soft	Unsensitized
FT-11	Half tone	Soft	Iso-orthochromatic
FT-12	Half tone	Soft	Iso-panchromatic
FT-12	Line	Normal	Unsensitized
FT-21	Line	Normal	Iso-orthochromatic
FT-22	Line	Normal	Iso-panchromatic
FT-30	Line	Contrast	Unsensitized
FT-31	Line	Contrast	Iso-orthochromatic
FT-32	Line	Contrast	Iso-panchromatic

As can be seen, the assortment of films produced by our industry for reproduction purposes is large enough to satisfy all reproduction requirements encountered in practice. However, the linear deformation of a film occurring when the temperature and humidity changes limits their use in the publication of maps.

In view of the fact that the industry does not produce photographic plates of large sizes (for the publication of maps one must have plates measuring from 40 x 50 to 100 x 120 cm), and the photographic films, owing to the considerable linear deformation (1-1.5%) have a limited use, cartographic enterprises are organizing, and some have already organized, the preparation of dry silver bromide plate directly in the cartographic factories themselves.

9. Preparation of Dry Silver Bromide Photographic Plates at the Cartographic Factory

To manufacture dry silver bromide plates and films in the cartographic factory it is necessary to have an equipped laboratory. It is better still if this laboratory consists of 2 adjacent rooms so that the processes requiring different illumination conditions can

run in parallel and independently. But the laboratory can also be organized in a single, sufficiently large room, although it is less convenient.

The principal equipment of the laboratory for the manufacture of dry silver bromide plates at the factory is a table for pouring the emulsion and a drying cabinet for drying the poured emulsion photographic plates. The table and the drying cabinet should permit the manufacture of photographic plates of sufficiently large sizes -- up to 100 x 120 cm, corresponding to the sizes of the sheets of the maps produced at the present time.

The table for pouring the emulsion and the pouring set-up should satisfy the following conditions:

1. Stable position of the glass both during the time of the pouring the emulsion itself, as well as the time that it is being cooled.
2. Installation of the glass in a strictly horizontal position and its levelling if necessary.
3. Illumination from below for control of the quality of the pouring by transmitted light.
4. Rapid cooling of the emulsion, poured on the glass.
5. Uniform pouring of the emulsion, insuring an identical layer of the required thickness over the entire surface of the plane.

An example of such a table is the table constructed at the TsNIIGAik (Central Scientific Research Institute for Geodesy, Aerial Photography, and Cartography) and used in the Scientific-Editorial Map-Compiling Part (MRKCh) (Figure 34). The table consists of 2 sections attached to each other, each representing a massive montage

table permitting operation with transmitted light; the cover of each section is an even thick and strong glass. Along the edges of the table (along both sections) there are fastened guiding metallic strips, on which moves a carriage, carrying the can for pouring the emulsion, and a container with ice to accelerate the cooling of the emulsion (after pouring). Each section is illuminated from underneath through suitable light filters depending on the character of the emulsion.

To set the glass prepared for the pouring in a horizontal position one employs a special device provided with adjustable lifting screws, permitting a change in its position in the horizontal plane.

An important part of the pouring device is the pouring can, which is a prolonged can made of stainless steel, in the bottom of which there are many small holes, through which the emulsion is poured onto the glass.

The drying cabinet should make it possible to dry photographic plates both with cold (room-temperature) air, as well as with heated air (up to 35-45° C) in relative short time (several hours). At the same time the construction of the cabinet must provide protection against dust carried in with the air stream, for this may spoil the plates. From this point of view it is preferable to have a drying cabinet in which the air moves downward. Finally, the dimensions of the cabinet should be such that plates of all sizes can be manufactured.

A drying cabinet satisfying the above conditions is the cabinet constructed by the TsNIIGAIK and used at the NRECh.

In addition to the pouring table and the drying cabinet one must have a water bath and a thermostatic bath for melting and maintaining the right temperature of the emulsion, a refrigerator to store it, and other auxiliary devices. The laboratory should be equipped with wash stands with cold and warm water, covered shelves for storage of the finished plates, supports for the glass, etc.

By way of an example, Figure 36 shows the diagram of a laboratory for the manufacture of dry silver bromide plates, equipped at the NRKCh and satisfying the imposed demands.

It is most advantageous to employ ready-made emulsion. The NRKCh uses a ready-made photographic emulsion of the diapositive type, produced by the second Moscow factory of photographic plates and photographic films, and having a light sensitivity of 0.5-0.8 in GOST units, a fog density D not greater than 0.02-0.03, a contrast coefficient not less than 2.5-3, a maximum density $D_{\max}$ not less than 3, and a photographic latitude 0.6-0.9.

Such an emulsion gives good results in contact work and satisfactorily results in projection photography of new originals that have not yet turned yellow, particularly study maps for elementary and middle schools.

The emulsion is received by the NRKCh in the form of a jelly and is stored in this form until it is used. One can also use a dry emulsion, but it is preferable to obtain emulsion in the form of a jelly. When working with a dry emulsion it must be dissolved, while in the case of jelly this can be dispensed with. True, dry emulsion can be stored for a long time, something that cannot be done with a jelly, this being a substantial shortcoming

of the latter. Nevertheless, if it is possible to obtain emulsion in small batches within short time intervals it is better to use emulsions in the form of jelly rather than dry.

Process of Preparation of Photographic Plate

The process of preparation of dry silver-bromide photographic plates consists of the following operations:

- (1) preparation of the glass;
- (2) preparation of the emulsion;
- (3) preparation of the pouring set-up;
- (4) pouring the emulsion on the glass and its cooling;
- (5) drying the finished plate.

The preparation of the glass consists of cleaning it of all dirt. Here the pickling, cleaning, and "polishing" of the glass is carried out with the same care as for the photography with the wet-colloid method. The underlayer is then placed on the well cleaned glass.

Of the many recipes for the underlayer, the best practical results are obtained with the underlayer developed at the TsNIIGAik with the following composition:

Purified gelatine	5 grams
Distilled water	1,000 ml
Chrome alum (10% solution)	5 ml
Rectified ethyl alcohol (96%)	25 ml
Carbolic acid	4 ml

The underlayer is coated on the pouring table manually (without a pouring device) with the aid of a strip of gauze. After coating the underlayer on the glass, it should be dried.

It is best to dry it in the drying cabinet at a temperature of approximately 40° C or without heating. The plate is ready for the pouring only after the underlayer is completely dry. The underlayer can be placed on the plate in ordinary electric illumination, so that the correctness of the process can be readily controlled.

The preparation of the emulsion requires special care, accuracy, and precision. If the emulsion is obtained in the form of a jelly, its preparation consists of melting, introducing the additives, and maintaining it at a definite temperature up to the very pouring.

The jelly is placed in a vessel (porcelain or glass chemical ware) and is melted in a water bath. During the melting of the jelly one must see to it that the temperature does not rise above 40° C. All the necessary additives are added to the molten jelly. As a result of prolonged experience, the following additives per liter of emulsion have been established at the NRKCh:

Chrome alum (10% solution)	4-12 ml
Rectified ethyl alcohol (98%)	20 ml
10% phenol (preservative)	2-3 ml

The emulsion is melted and the additives are added with constant stirring. The molten emulsion with the additives are placed for 10-15 minutes in a thermostatic bath, where it is kept at a temperature of 40°. This operation is necessary to eliminate the air bubbles formed during the mixing, which may make the pouring difficult if not eliminated.

The preservative is added to the emulsion in those cases when the plates must be stored for a prolonged time (more than 3 days). If the plates are used immediately in production there is no absolute need for the preservative.

The chrome alum is added to the emulsion in the summertime or if the photography and particularly the processing of the negatives is carried out in rooms with sufficiently high temperatures (above 25°C). If the negatives are processed at a relatively low temperature (not above 18° C), the chrome alum can be omitted or used in small quantities. At the NRECh one usually adds in the summertime 10-12 ml of 10% solution of alum per liter of emulsion, and in the summer 2-4 ml or nothing at all.

The viscosity of the emulsion is of very great importance in the final results of the pouring. The optimum viscosity is one in which the small stream of emulsion smoothing flows as a result of the motion of the pouring can, and this is best established experimentally. If the viscosity of the emulsion is too high and the jets poured from the can spread too slowly, the glass becomes unevenly coated, then distilled water is added to the emulsion to dilute it to the required consistency. If, on the other hand, the viscosity of the emulsion is not high enough, it can be increased by adding molten gelatine to the solution. The emulsion is prepared under illumination conditions corresponding to its character. In practice it is advisable to perform this process in red light for all emulsions except for panchromatic. Experience has shown that even in the case of unsensitized dispositive emulsions, an orange filter is not satisfactory. If the laboratory consists of 2 rooms, the emulsion is best prepared in parallel with the preparation of the glass, (placing the underlayer) but in different rooms.

If the emulsion is used not in the form of a jelly, but dry, it must first be soaked in distilled water, and then molten in a water bath. Its viscosity is brought to the required value, after

which the additives are added. All operations with dry emulsions are also carried out in red light.

The preparation of the pouring equipment consists of:

- (a) setting the glass up on the pouring table;
- (b) preparing the pouring can;
- (c) setting and adjusting the position of the pouring can.

Setting the Glass up on the Pouring Table. To ensure an emulsion layer that is uniform for the entire surface of the glass, the glass must be placed in a horizontal position. The latter is obtained by means of adjusting screws of the mounting. For this purpose the glass is laid on the mounting and a level is used to check in 2 mutually perpendicular positions how strictly horizontal the glass is. Turning the regulating screws, the glass is placed in a horizontal position. The bubble and the level must not deviate from the center by more than half a division.

Preparation of the pouring can consists of a thorough washing of the can in hot water. The washing is necessary to prevent accidental contamination of the emulsion when pouring on the glass. Hot water is used for the purpose of melting and washing out possible remnants of jelled emulsion from the can, which may have remained in the corners, holes, and other places of the can after pouring.

The setting and adjustment of the can position affects the quality of the pouring. Of great significance is its height above the glass and the space between the glass and the can, which must be the same over the entire length.

Operating experience has shown that the shape of the can and the number and size of the holes are of great significance to the quality of the photographic plate, and particularly for the thickness of the emulsion layer and its uniform distribution over the glass. Good results are obtained with the can used in the shop for the preparation of forms of the MRACh (Figure 37), in which holes 0.6 mm in diameter are spaced 5 mm apart.

The can is attached on a special carriage, which moves on guides along the pouring table. The carriage is equipped on both ends with adjusting screws, which make it possible to change its height over the table, and consequently the can can also occupy various positions in height relative to the glass. In addition, the can is held on both ends with special rubber rings, which cover holes that are unnecessary in certain cases, preventing thereby an excessive loss of emulsion, and ensuring simultaneously a constant gap between the can and the glass in the working position.

After the can is placed on the carriage, it is put in operating position and moved slowly along the entire glass. In the case the rubber rings must touch at all times the edges of the glass, and the gap between the can and the glass should be uniform at all times. After checking that this condition is satisfied, the carriage and the can are pushed to the rear. The can is removed from the carriage and heated again, washed with hot water, and then dried with clean cloth and mounted on the carriage in the inoperative state. The emulsion, heated to 40° C, is poured into the can, which is then moved to the edge of the glass, rotated to the working position, and the emulsion is then poured on the glass.

Pouring the Emulsion on the Glass. When the can is turned in

the working position, the emulsion pours on the glass through the holes in thin streams and immediately spreads over the glass. This is why the speed of the carriage and can is of great importance. The slower the carriage moves, the more emulsion is poured on the glass, and to the contrary, the faster it moves, the less emulsion will be poured on the glass. Since the carriage is moved manually, experience in uniform motion at a certain speed along the entire glass is of great importance. The carriage must move smoothly during the total pouring time. Uneven motion of the can may lead to an uneven thickness of the emulsion layer on the finished photographic plate, making it unsuitable for fine photo-reproduction work in the publication of map. The idea that the emulsion can be poured in from a tea kettle is valid only in that case when the photographic plate is made for auxiliary reproduction work and it is not needed to copy printed forms.

In practice, the following norms for pouring liquid emulsion have been established at the NRKCh:

for plates measuring 40 x 50 cm	100 ml
for plates measuring 50 x 60 cm	150 ml
for plates measuring 70 x 80 cm	280 ml
for plates measuring 80 x 100 cm	400 ml
for plates measuring 80 x 110 cm	440 ml
for plates measuring 90 x 110 cm	500 ml
for plates measuring 100 x 120 cm	600 ml

The emulsion poured on the glass must be rapidly cooled, so that the glass with the emulsion coating can be moved to the cabinet for drying. For this purpose a box with ice is placed over the plate. When the emulsion is sufficiently cold (this usually takes 4-6 minute), the plate is carried to the drying cabinet.

The construction of the table (Figure 34) makes it possible to perform the work in such a way that while one plate (for example on the first section) cools, the emulsion can be poured on a plate in the second section.

All the pouring operations must be carried out with illumination corresponding to the character of the emulsion. It is best to work in red light even when pouring unsensitized emulsions.

The drying of the finished photographic plate is carried out in the drying cabinet. The plate is placed in the cabinet in a vertical position and remains in it without heating and without blowing of air for approximately one hour, after which the air is first turned on for 15-20 minutes after which the heat is turned on. The temperature is gradually increased, and the already-partly-dried emulsion layer becomes dried out relatively rapidly. The temperature must not be increased above 40 °C. Drying lasts 5-6 hours under the above conditions.

The drying and particularly the storage of the finished photographic plates is carried out either in darkness or in dark-red light even in the case of unsensitized emulsions. It is best to store plates in a vertical position in covered shelves.

Operating experience at the NRKCh shows that the photographic plates produced within the factory can be used for a great variety of photo-reproduction work. For example, in the publication of the world's atlas they were used for contact-preparation of the diapositives and negatives. In the publication of various teaching maps these plates are successfully used for projection preparation of the negatives.

They are suitable for the preparation of halftones and screen negatives. Photographic plates manufactured directly at the cartographic enterprise can be used over a wide range, making it unnecessary in many cases to use the more expensive and the less suitable wet-coloidion method.

CHAPTER 4

PHOTO REPRODUCTION PROCESS USING DRY SILVER BROMIDE PLATES AND FILMS

The process of preparing a negative can be subdivided into the following stages:

- (1) set-up of the camera;
- (2) exposure;
- (3) development of the latent image;
- (4) fixing the developed image;
- (5) final processing of the resultant negative;
- (6) finishing the negative.

10. Set-up of the Camera

By "set-up of the camera" one understands the fastening of the original to the screen, determination of the size of the image on the ground glass, set-up of the photographic plate in place of the ground glass, and illumination of the original.

The original must be attached in the center of the screen so that there is no skewing. The vacuum on the screen must be maintained at not less than 50-60%, so as to ensure an unchanging position of the original during the entire time of exposure.

After the original is attached to the screen, the dimensions of the image are established on the ground glass, i.e., the correct

relative positions of the objective, original, and ground glass are established taking into account the specified scale of the photograph.

It is known from elementary optics that the distance from the photographed object to the center of the objective of the photographic camera and from the objective to the image of this object are related by a definite equation, which is mathematically expressed as follows:

$$\frac{1}{a} + \frac{1}{b} = \frac{1}{F}$$

where F is the principal focal distance of the objective, which is always marked on the mount of the objective; a is the distance from the optical center of the objective to the photographed object, and b is the distance from the optical center of the objective to the image of the photographed object (Figure 38).

The quantities a and b depend on whether the object is photographed in natural scale, with reduction, or with magnification. If the ratio of the dimensions of the image to the dimensions of the photographed object, i.e., the scale of the photograph, are denoted by n, the quantities a and b can be calculated from the following equations

$$a = F\left(\frac{1}{n} + 1\right); \quad b = F(n + 1).$$

It follows from the above equations that in photography in natural size $a = b = 2F$, because $n = 1$ and $1/n = 1$.

The photographer usually determines the relationships by inspection, and then establishes the position of the camera at which the required dimensions of the image are obtained by prolonged and multiple measurements on the ground glass. A simpler and faster method is to calculate first the values of a and b and to set the

camera accordingly. It is still necessary to make additional adjustments after this, owing for example to insufficiently precise setting of the camera, but these will nevertheless be quite insignificant.

To clarify the above let us analyze the following actual example.

Assume that it is necessary to photograph a publisher's original of a map, drawn with the sides magnified one and a half times compared to the published dimensions.

Since n is the ratio of the dimensions of the image to the dimensions of the original, its value will be $1/1.5 = 0.667$. If the focal distance of the objective is known, for example 90 cm, it is possible to calculate a and b , by substituting the values of n and F into the equations

$$a = F(1/n + 1) = 90 \text{ cm } \left(\frac{1}{1.5} + 1 \right) = 225 \text{ cm};$$

$$b = F(n + 1) = 90 \text{ cm } (1/1.5 + 1) = 150 \text{ cm}.$$

A rule or measuring tape are used to set the camera, by assuming the optical center of the objective to the ring of the diaphragm, and a sharp image is obtained automatically in the specified dimensions.

If, to the contrary, it is necessary to increase the image of the original by one and a half times compared with its natural size, then substituting the value $n = 1.5$ into the equations, we obtain

$$a = F(1/1.5 + 1) = 90 \text{ cm } (0.667 + 1) = 150 \text{ cm};$$

$$b = F(1.5 + 1) = 90 \text{ cm} \cdot 2.5 = 225 \text{ cm}.$$

It is advisable to compile a table of values of a and b for various magnifications and reductions when operating with objectives of different focal distances. By way of example, let us show a table, where the values of a and b are calculated in cm for the most frequently encountered cases.

TABLE 6

F	n	F = 45 cm		F = 60 cm		F = 75 cm		F = 90 cm		F = 120 cm	
		a	b	a	b	a	b	a	b	a	b
0.1		495.0	49.5	660.0	66.0	825.0	82.5	990.0	99.0	1,320.0	132.0
0.2		275.0	54.0	360.0	72.0	450.0	90.0	540.0	108.0	720.0	144.0
0.3		195.0	58.5	260.0	78.0	325.0	97.5	390.0	117.0	520.0	156.0
0.4		157.5	63.0	210.0	84.0	262.5	105.0	315.0	126.0	420.0	168.0
0.5		135.0	67.5	180.0	90.0	225.0	112.5	270.0	135.0	360.0	180.0
0.6		119.8	72.0	160.0	96.0	200.0	120.0	240.0	144.0	320.0	192.0
0.7		109.3	76.5	145.7	102.0	182.2	127.5	218.6	153.0	291.5	204.0
0.8		101.2	81.0	135.0	108.0	168.8	135.0	202.5	162.0	270.0	216.0
0.9		95.0	85.5	126.7	114.0	158.3	142.5	190.0	171.0	253.3	228.0
1.0		90.0	90.0	120.0	120.0	150.0	150.0	180.0	180.0	240.0	240.0
1.1		89.5	94.5	114.5	126.0	143.2	157.2	171.8	189.0	229.1	252.0
1.2		82.5	99.0	110.0	132.0	137.5	165.0	165.0	198.0	220.0	264.0
1.3		79.6	103.5	106.1	138.0	132.7	172.5	159.2	207.0	212.3	276.0
1.4		77.1	108.0	102.8	144.0	128.6	180.0	154.3	216.0	205.7	288.0
1.5		75.0	112.5	100.0	150.0	125.0	187.5	150.0	225.0	200.0	300.0
1.6		73.1	117.0	97.5	156.0	121.9	195.2	146.2	234.0	195.0	312.0
1.7		71.5	121.5	95.3	162.0	119.1	202.5	142.9	243.0	190.6	324.0
1.8		70.0	126.0	93.4	168.0	116.7	210.0	140.0	252.0	186.7	336.0
1.9		68.7	130.5	91.6	174.0	114.4	217.5	137.3	261.0	183.1	348.0
2.0		67.5	135.0	90.0	180.0	112.5	225.0	135.0	270.0	180.0	360.0

The photographer determines visually on the ground glass how accurately the dimensions obtained by him agree with the specified dimensions, and also how sharp and clear an image is obtained. One difficulty involved is that he sees the image not directly, but through a thickness of glass. This may cause errors due to parallax.

When checking the image, the photographer places the rule not in the plane on which the image is projected, but in a different plane, somewhat behind the image plane, and he tries to align scale divisions that are in different planes (for examples, the division on the measuring rule and the corner of an inner frame, Figure 39). Depending on the position of his eye, he may read on the rule either o or o_1 or o_2 . Since the readings (or the alignments of the initial divisions) are made on both ends of the rule, to eliminate errors in the dimensions it is necessary to strive to read the rule while keeping an identical position of the eye relative to the image.

The determination of the sharpness of the image through the glass also requires a certain experience, and is facilitated by viewing the image best of all through a magnifier with a 6-8 times magnification.

Once the image has been brought to the required size and focused, the ground glass is removed and replaced by the holder with the photographic plate. The holder is inserted very carefully and accurately with its slide closed and with the objective closed, so as not to disturb the setting of the camera and so that the plate with its light sensitive layer is exactly in the plane formerly occupied by the ground glass. To expose the photographic plate it is necessary to remove the slide of the holder and the objective after first checking the illumination of the original.

To obtain a good negative from a line drawing it is necessary that all the parts of the plate obtain equal and maximum permissible exposure corresponding to the given photographic emulsion and to the given quality of the original. If we neglect the uneven distribution of the light caused by the lens, the only condition for fulfilling this requirement is to apply uniform illumination to all the parts of the original. For this purpose it is necessary to arrange the fixtures properly relative to the original.

To obtain uniform illumination of the original, the light fixtures (if they are all equal) to be placed on both sides of the original at an equal distance from the center at an angle of $30-45^{\circ}$ to the plane of the original. It is possible to check for the correctness of the placement of the lights in the following manner. A small rule or a pencil is placed next to the glass of the screen at the center of the original. If the shadows from this object arrange themselves on 2 (or 4) sides of the pencil with equal density and with equal length, this is evidence that the lights are placed correctly.

Experienced photographers can, by clever manipulation of the light, compensate to some extent for individual shortcomings of the original (uneven background etc), by bringing the lights closer to the original or farther away at certain portions of the original. In individual cases, for example when the light losses become noticeable at the edges of the plate owing to the uneven distribution of the light by the objective (see Section 6), the losses must be made up by suitable placement of the lamps so as to reinforce the illumination of the edges of the original relative to the illumination at its center.

11. Development of the Latent Image

Before proceeding to discuss developers and the technique of development let us become acquainted with a very important chemical concept, of great importance for this and subsequent sections, namely the pH.

It is known that water dissociates into ions (true, to a very small extent) in accordance with the equation $H_2O \rightleftharpoons H^+ + OH^-$, and since the product $H^+ \cdot OH^-$ remains constant ($H^+ \cdot OH^- = \text{const}$), an increase in the concentration of the hydrogen ions (H^+) is accompanied by a reduced concentration of the hydroxyl ions (OH^-). In pure water, which is chemically neutral, the amounts of H^+ and OH^- are equal and the product of the concentrations was found by measurement to be 10^{-14}

$$H^+ \cdot OH^- = 10^{-14}$$

Consequently, in pure water (neutral solution) the concentration of $H^+ = 10^{-7}$ and the concentration of $OH^- = 10^{-7}$.

If acid is introduced into the water, the concentration of H^+ increases and consequently the concentration of OH^- decreases. Conversely, introducing an alkali increases the concentration of the hydroxyl ions, i.e., of OH^- , and correspondingly decreases the concentration of the hydrogen ions H^+ ; the product of the 2 remaining 10^{-14} . Thus, if the addition of acid into a solution causes the concentration of the H^+ ion to rise, for example, to 10^{-4} , the concentration of the OH^- ions will drop to 10^{-10} , and to the contrary, if introducing alkali into water (or into a solution) raises the concentration of the OH^- ions to 10^{-4} , the concentration of the H^+ ions will drop to 10^{-10} .

Thus, the exponent of the concentration of H^+ or OH^- can serve as a measure of the acidity or alkalinity of solutions. Such a measure is taken to be the exponent of the concentration of the hydrogen ions, taken with the reverse sign. The adopted unit for the measurement of degree of acidity or alkalinity of a solution is called the hydrogen number and is denoted by the symbol pH.

The values of H^+ and OH^- for solutions having acid and alkali reaction and the corresponding values of pH are given in Table 7.

TABLE 7

Reaction of solution	Concentration of hydrogen ions H^+	Concentration of hydroxyl ions OH^-	Value of pH
	$10^{-1} = 1$	10^{-14}	0
Strongly acid	10^{-1}	10^{-13}	1
	10^{-2}	10^{-12}	2
	10^{-3}	10^{-11}	3
	10^{-4}	10^{-10}	4
Weakly acid	10^{-5}	10^{-9}	5
	10^{-6}	10^{-8}	6
	10^{-7}	10^{-7}	7
Neutral	10^{-8}	10^{-6}	8
	10^{-9}	10^{-5}	9
	10^{-10}	10^{-4}	10
	10^{-11}	10^{-3}	11
Weakly alkaline	10^{-12}	10^{-2}	12
	10^{-13}	10^{-1}	13
	10^{-14}	$10^0 = 1$	14

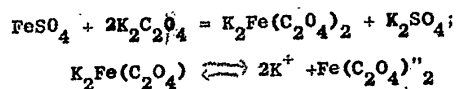
The determination of the degree of acidity or alkalinity of solutions, i.e., pH control, is of great importance to photographic and other publishing processes.

The developers used for chemical development consist usually of the following components:

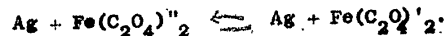
1. Developing substance.
2. Preservative.
3. Accelerator.
4. Various special additives.

Developing substance. Developing substances may be certain chemical reducers of inorganic or organic origin. Inorganic developers have been known earlier than organic ones and have been used in photography before the discovery of the latter. Such developers are, for example, certain ferrous salts.

The action of inorganic developers can be illustrated with an example of the ferric-oxalate developer, the principal component of which is potassium oxalate ($K_2C_2O_4$) and ferrous sulfate ($FeSO_4$). In this case the reactions take place as follows:



and further on



At the present time, when working with dry photographic emulsions, the developers used are not inorganic but organic, particularly derivatives of benzol, diphenyl, and naphthalene. Of the many known organic developers, the most widely used at the present time are hydroquinone, metol, paraaminophenol, pyrogallol, pyrocatechin, glycin, amidol, atomal, and several others.

Some organic developers, as well as inorganic ones, have the ability to develop in an alkaline medium, and others, to the contrary, in an acid medium. Most organic substances used at the present time reduce the grains of the silver halide, i.e., they have developing properties, in an alkaline medium. Here, as a rule, increasing the pH of the solution increases the speed of development.

The concentration of the developing substance in the developer affects the speed of the development. Increasing the concentration of the developing substance to a certain limit increases the speed of development. Further increase in the concentration of the developing substance, without increasing the speed of development, increases the fog and consequently reduces the contrast.

The following concentrations of developers, in grams/liter of developer, are considered optimum for ordinary black and white photography [8]:

Metol	6
Hydroquinone	6
Pyrocatechin	6
Para-aminophenol	5
Pyrogallol	5
Amidol	4

If along with increasing the concentration of the developing substance one increases the alkalinity of the solution (its pH), it is possible to eliminate or reduce the fog formation.

Developing solutions with alkaline organic developers oxidize rapidly by the oxygen in the air and lose their developing ability.

They must therefore be stored in containers that prevent the access of air, and should be kept as little as possible in the trays, where the surface of contact with the air is large.

Preservatives. By way of preservative one employs exclusively sodium sulphite (Na_2SO_3) in the form of anhydrous or crystalline salt. Up to recently it was believed that the role of the sulphite is only to preserve the developing substance against oxidation, and thus maintain the developing ability of the developer. Later investigations have shown that in the presence of an organic developer the sulphite oxidizes much more slowly. Thus, apparently, the sulphite and the developing substance oxidize more slowly in the developing solution if they are together, than if they were separately. At the same time, the developing solution retains its operating properties for a longer time. In addition, the sulphite solutions are solvents for the silver halide and particularly for silver bromide, and this facilitates the access of the developing substance to the centers of development, located inside the emulsion grain, and consequently, accelerates the development process. The sodium sulphite restores the developing ability of certain developing substances (for example, hydroquinone), and this too makes its presence desirable in the developer.

Along with the sulphite, and sometimes in lieu of it, the preservative used is potassium metabisulphite ($\text{K}_2\text{S}_2\text{O}_5$) or sodium bisulphite (NaHSO_3). The equivalent amounts of the above salts are given in Table 8.

TABLE 8

Name of salt	Chemical formula	Equivalent amounts
Sodium sulphite anhydrous	Na_2SO_3	1,000
Sodium sulphite crystalline	$\text{Na}_2\text{SO}_3 \cdot 7\text{H}_2\text{O}$	2,000
Potassium metabisulphite	$\text{K}_2\text{S}_2\text{O}_3$	0.880
Sodium metabisulphite	NaHSO_3	0.825

Accelerator. The accelerating substances used for ordinary developers are carbonate alkalies, and for high speed and superhigh speed developing solutions caustic alkalies are used. Among the caustic alkalies employed are potassium hydroxide (KOH) and caustic soda (NaOH), and among the carbonate alkalies are sodium carbonate (Soda -- Na_2CO_3) and potassium carbonate (potash -- K_2CO_3). The equivalent amounts of carbonate salts in the developing solution are given in Table 9.

TABLE 9

Name of salt	Chemical formula	Equivalent amounts
Sodium carbonate		
anhydrous (anhydrous soda)	Na_2CO_3	1.0
Sodium carbonate crystalline	$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$	2.7
Potassium carbonate (potash)	K_2CO_3	

The reason the carbonates or caustic alkalies are called accelerators for developers is because almost all the organic developing substances used have reducing properties only in an alkali medium ($\text{pH} > 7$). In the absence of alkali the development is exceedingly slow and the process stops rapidly. This effect of the alkali is apparently explained by the fact that by increasing the dissociation of the

substances dissolved in the developer, it contributes to ionic reactions between the developing substance and the silver halide. This also explains the fact that increasing the pH of the developing solution increases the speed of development. Thus, in fine-grain developers the pH is on the order of 8; in rapid and vigorous developers the pH of the solution reaches 12 and sometimes more. The speed of development of all the developing substances used in practice increases with increasing pH of the solution, and as can be seen from Figure 40 [8], where the speed of development can be judged from the resultant optical densities of the image.

Thus, caustic alkalis are used in the developer for rapid development, and carbonates are used for slow development. It must be borne in mind that caustic alkalis strongly increase the swelling of the gelatine and cannot always be used.

Special Additives. These components are introduced into the developing solutions to reduce the fog formation and to increase the strength of the light-sensitive emulsion. Depending on the particular purpose of the developer, the different additives are added accordingly.

The most widely used antifogging substance is potassium bromide, which when added to the developing solution increases the concentration of the Br^- ions and correspondingly decreases the concentration of the Ag^+ ions, and thus slows down the development. Since the retarding action of potassium bromide manifests itself to a greater degree in the first, initial stage of the development, it leads to a reduction in the fog.

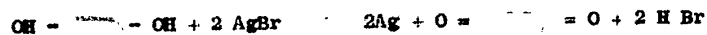
An antifogging substance widely used in recent times is benzotriazol, small concentrations of which give good results.

To harden the emulsion layer, one introduces into the developer substances that exert a tanning action on the gelatine. Such substances are alums, with potassium alums being employed most.

Sometimes the antifogging and hardening substances are introduced into the developer simultaneously.

From the concept of the developing process as an oxidation-reduction process, during which the developing substance reduces the Ag^+ ions and becomes itself oxidized thereby, we also obtain a concept of the chemical reaction of development, which can be represented by the schemes given below [8].

For hydroquinone this reaction can be written as follows:

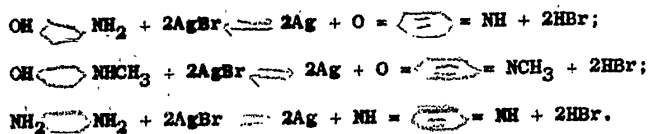


or in ionic form



We see that this is in agreement with the theoretical ideas concerning the development process, given in Section 3. The negatively charged ions of the developing substance, which appear as a result of the dissociation of the latter in the developing solution, deliver their electrons to the silver ions, converting them into silver atoms and themselves becoming oxidized. The hydrobromic acid liberated thereby is neutralized by the alkali located in the development, and consequently the alkalinity of the solution diminishes and the developing solution is gradually exhausted.

If para-aminophenol, metol, or paraphenyl diamine are used, the reactions can be expressed by the following schemes respectively:



The above schemes naturally do not give an exact representation of the course of the reactions, occurring during the developing process, which become considerably complicated by the presence of other components in the developer, particularly sodium sulphite, for actually the sulphite and the developing substance are oxidized together by the silver halide and by the oxygen in the air,

However, they give a correct idea concerning the chemistry of the development process.

In practice a very large number of a great variety of developing formulas exist and are in use. An idea of this can be gained from the data given in Table 10 [8].

The duration and speed of development are of great importance. As indicated above, the speed of development of dry silver bromide photographic emulsions increases with increasing pH of the developing solution. It also increases with stirring of the developing solution. From this point of view, the most suitable trays are those adapted for mechanical rocking. If the developer tray is not rocked, the development process slows down and may be uneven. The reason for this is that the diffusion process of the developing solution into the depth of the emulsion and their reaction products from the emulsion to its surface occur more rapidly than the process of the spontaneous stirring of the developing solution. This results in an accumulation of development-reaction product in the developing solution at the surface of the photographic layer, an exhaustion of the layer of development that is in

TABLE 10

COMPONENT SUBSTANCES IN GRAMS PER LITER OF DEVELOPING SOLUTION

Name of developer	metol 2	hydro- quinone 3	para- amino- phenol 4	amidol 5	sodium sulphite 6	pot. metabi- sulphite 7	sodium bisul- phite 8	anhy- drous soda 9	soda caustic 10	pot. alum 11	pot. bromide 12	citric acid 13	benzotriazole 14
1													
Metol-hydroquinone (K. V. Chibisov's)	1	5	-	-	52	-	-	20	-	-	1	-	-
Positive metol-hydroquinone NIKFI (P-1)	2	6	-	-	40	-	-	25	-	-	3	-	-
Positive metol-hydroquinone NIKFI (D-16)	0.3	6	-	-	74.5	1.5	-	19	-	-	0.9	0.75	-
Positive metol-hydroquinone NIKFI (P-5)	1	6	-	-	75	-	-	30	-	-	2	-	-
Metol-hydroquinone for aerial photography	5	8	-	-	80	-	-	40	-	-	4	-	-
Para-aminophenol hydroquinone with soda	-	2.5	3.5	-	50	-	-	30	-	-	1	-	-
Positive para-aminophenol- hydroquinone with soda (P-3)NIKFI	-	1.5	1.7	-	45	-	-	-	2	-	3	-	-
Amidol (without alkali)	-	-	-	5	50	-	-	-	-	-	1-2	-	-
Aluminate buffer	-	5	-	-	60	-	-	-	40	30	3	-	-
Rapid hydroquinone (D-9)	-	11.3	-	-	-	-	11.3	-	26.2	-	11.3	-	-
Rapid hydroquinone NIKFI(PK-1)	-	25	-	-	140	-	-	-	28	-	25	-	-
Super-rapid metol-hydroquinone (SD-27)	5	45	-	-	180	-	-	-	40	-	10	-	1

contact with the developed material, and as a result, a slow-down and even cessation of the development. Since a different amount of reaction products can be formed at different parts of the image (for example, in the development of a halftone image), the speed of development may be different at various parts of the negative, leading to great distortion in the reproduction of the distribution of the light and shadow of the photographed object. It is therefore quite essential to stir the developing solution during the time of development.

The duration of the development, affecting many sensitometric indices of the emulsion, depends on the composition of the developing solution and on its alkalinity (pH). An idea of the dependence of many sensitometric indices of the developed photographic image on the development duration can be gained from Figure 41 [8].

In the metol-hydroquinone developer ordinarily used in map publishing (for example, developer KTs-1) the duration of the development amounts to 4-5 minutes. To increase the time of development above 4-5 minutes is unadvisable because this increases not only the optical density of the exposed image, but also the density of the fog. This can be seen at a glance from the curves of Figure 42 [8].

Higher values of pH of the solution correspond, other conditions being equal (including also the length of development), to higher values of the resultant optical densities of the image. This is apparently caused by the increase in degree of dissociation of the developing substances in the solution with increasing pH of the latter, and the large concentration of the developer ions imparts a high reducing ability to the solution.

An idea of the dependence of the blackening on the pH of the developing solution at various lengths of development is given by Figure 43 [8].

The use of rapid and super-rapid developing solutions in map publishing is hardly recommended. One of the specific features of map-publishing reproduction is the fact that visual control is essential in the performance of the process, and rapid and super-rapid developer, which develop the image within a few seconds or even within a few tenths of a second, make it impossible to control visually the development process.

Of great significance is the correct illumination of the laboratory where the development takes place. Taking into account the color sensitivity of various photo-technical materials, they can be developed in the following illumination: orange light for unsensitized material, red for orthochromatic, and total darkness for panchromatic.

However, taking into account the actual facilities at map-publishing enterprises, it is advisable to develop all silver-bromide photographic emulsions except panchromatic in red light, and panchromatic, in accordance with their spectral sensitivity, in total darkness.

The developed image must be rinsed before fixing, so as to wash off the developer remaining on the surface of the plate (or film). Such washing, however, does not stop the development. This process continues because of the developer remaining in the photographic emulsion. To stop the development process the material must be treated in an oxidizing stop bath (pH = 5-6) or to carry out the fixing in an acid fixing solution.

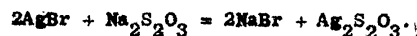
12. Fixing the Image

The development does not terminate the photographic process. The developed emulsion layer contains both developed and undeveloped grains. If light is to act on the photographic emulsion, the newly formed latent image in the grains that were previously not subjected to the action of light would be developed by the developer impregnated in the emulsion layer and cause blackening of the plate. To prevent this, the photographic plate (or film) is subjected to a treatment called fixation. Preparations with which this treatment is performed are called fixing solutions or fixers.

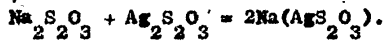
The fixing process consists of converting the grains of silver halide that are insoluble in water into water-soluble compounds, by means of several reactions, so that they can be readily washed out from the emulsion layer. Since only 15-20% of the silver halide is used up in the formation of the image [8], the remaining 80-85% must be removed from the emulsion.

The fixing material employed is a solution of sodium thiosulfate ($\text{Na}_2\text{S}_2\text{O}_3$), known in the trade as hypo.

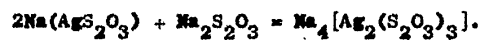
Up to recently it was assumed that when the developed photographic film (or plate) is immersed in the solution of hypo, the silver bromide reacts with the hypo in accordance with the following scheme



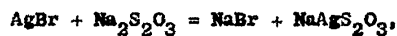
At this stage of the process there is formed, as we can see, silver thiosulfate, which does not dissolve in water. But in the presence of excess hypo the silver thiosulfate formed reacts with it in accordance with the formula



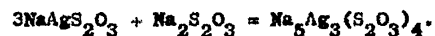
The resultant salt dissolves in water with difficulty, but in an excess of hypo the reactions continue and the resultant complex salt becomes transformed into another, which is readily soluble in water. The reactions are in accordance with the following scheme:



The latest theory is that the chemical process of fixation can be represented also with the following scheme. During the first stage of the process, the reaction



results in formation of a complex salt, which dissolves with difficulty in water and which reacts with the excess hypo contained in the fixer to form a second complex salt, which is well soluble in water. The reaction here follows the scheme



The fixation process can occur only in the presence of an excess amount of hypo, meaning that the fixing solution cannot be used to exhaustion.

The principal factors affecting the speed of fixation are the concentration of the hypo in the fixing bath, the property of the emulsion layer, the temperature of the fixing bath, and the influence of the various components introduced into it. The concentration of the hypo exerts a great influence on the speed of fixation. The plot of Figure 44 gives an idea of this dependence. As can be seen, the speed of fixation increases up to hypo concentrations of 30-40% in the bath. At such a concentration the duration of the

fixation at a bath temperature of approximately 18° does not exceed 4 minutes. Further increase in the concentration of the hypo results not in an acceleration, but in a considerable retardation of the fixation process. An adequate practical concentration of hypo in the fixing bath is 25%.

The above graph shows that when the hypo concentration is reduced (for example, by exhaustion during the fixation process) the speed of fixation also decreases.

The fixation mechanism consists of diffusion of the hypo solution into the thickness of the swelling emulsion, reacting there with the silver bromide, and diffusion of the reaction products from the emulsion into the solution. Therefore, everything that accelerates diffusion accelerates the fixation process, and vice versa. Raising the temperature of the bath accelerates the fixation process. However, it must be borne in mind that increasing the temperature of the fixing bath above 22-24° C softens the emulsion layer and consequently, weakens it. This is undesirable, for the emulsion can be readily damaged.

Stirring the solution also accelerates the fixation (by approximately 15-20%).

The influence of stirring the solution on the speed of fixation is shown in Table 11.

Material	Concentration of hypo per liter of fixing bath	TABLE 11 Time of illumination, seconds		
		No stirring	Stirring every 30 sec	stirring Continuous/
Panchromatic negative film	350	120	120	105
Positive film	100	150	120	90

The speed of fixation depends on the properties and character of the light-sensitive emulsion. Fine-grain emulsions, for example, are fixed more rapidly than coarse-grain ones (Figure 45), and thinner emulsions are also fixed faster.

Certain salts introduced into the fixing bath accelerate the fixation (ammonium chloride, ammonium thiocyanate). Thus, for example, a fixing bath consisting of 40-50% solution of ammonium thiocyanate requires several times less fixing time than a hypo solution. It must be borne in mind, however, that ammonium thiocyanate softens the photographic emulsion considerably and can be used very carefully only if the emulsion layer is hardened.

Table 12 gives data on the speed of fixation (emulsion clearing time) obtained using solutions of various thiosulfates [8].

TABLE 12

Fixing Substance	Clearing time		Optimum data at 15° C	
	50% solution	15% solution	Clearing time	Concentration of solution, %
Calcium thiosulfate	-	-	4 min	55
Sodium thiosulfate (hypo)	2.75 min	6 min	1 m 55 sec	40
Potassium thiosulfate	-	-	4 min	30
Ammonium thiosulfate	28 min	1 m 20 sec	1 m 20 sec	15

When working with dry silver bromide photographic emulsions it is best to use acid fixers, for in them the development process stops immediately while in ordinary fixers the development continues for some time owing to the developer remaining in the emulsion after the plate is immersed in the fixing bath. It is also advisable to use a short bath, in which the negative is rinsed after development before emerging into the fixing solution.

It is best to carry out the fixation in 2 trays, with the negative kept in the first tray up to the visible disappearance of the silver bromide, after which it is transferred to the second bath. The instructions recommend the negative to be kept in the second bath for another 10-12 minutes. The negative should be rinsed in water after the first and before the second fixing bath.

When working with large scale negatives (for example, 90 x 110 or 100 x 120 cm) in confined working places they can be fixed also in a single bath, but in this case the negative must be kept in the fixing bath not less than 10 minutes after visible disappearance of the silver bromide.

After fixing the negative should be well washed in running water. Thorough washing is essential for complete elimination of the hyposulfite and the reaction products from the emulsion. If any of these are not sufficiently well eliminated from the negative, yellow spots will be formed in the negative after a certain time and will spoil the image, and this affects particularly the quality of halftone negatives. The instructions therefore recommend that washing be carried out for 20-25 minutes.

13. Reduction and Intensification of the Negative

In practice it becomes frequently necessary to reduce or intensify the negatives owing to incorrect performance of the reproduction process (overexposure, underexposure), poor quality of originals, or shortcomings of the photographic emulsion (for example, fog). Even though the operations of reduction and intensification of silver bromide negatives are auxiliary, nevertheless their correct performance is of great importance to the quality of the negatives.

Reduction of Negatives

The reduction of the negative consists of eliminating from the surface a certain amount of silver, forming the image. Solutions with which the reduction is carried out are called reducers.

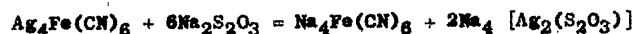
By their operating character, reducers can be subdivided into 3 groups [17]: reducers which eliminate an equal amount of silver from all parts of the image, which are called surface reducers; reducers eliminating the silver in proportion to its amount at a given location, which are called proportional; and reducers eliminating more silver from dense spots of the image and less from less dense ones, which are called superproportional. The most widely used reducer in mine photo reproduction (particularly in map publishing) is Farmer's surface reducer, consisting of potassium ferri-cyanide and hypo.

The reduction consists of converting part of the metallic silver into soluble salts and removal of these salts from the emulsion.

The chemical reaction of the reduction with Farmer's reducer consists of 2 stages. In the first stage the potassium ferricyanide oxidizes the metallic silver, converting it into silver ferricyanide in accordance with the following equation



The resultant potassium ferricyanide ($\text{K}_4\text{Fe}(\text{CN})_6$) dissolves in water and the silver ferricyanide, reacting with the hypo, becomes converted into soluble complex salt in accordance with the formula

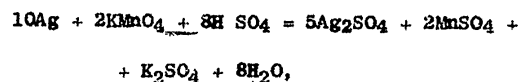


and is also removed from the emulsion.

It must be borne in mind that in the reduction it is possible to correct only slight defects in the negative (slight fog, haloes around the screen points, weak shadow on the blank field of the positive, etc).

Farmer's reducer is an unstable compound, which retains its properties for 3-4 minutes. The potassium-ferricyanide and hypo solutions are therefore prepared separately and are mixed only immediately before use.

Amongst the proportional-type reducers, which, true, are not as widely used, is the potassium permanganate reducer, which consists of 0.1% solution of potassium permanganate (KMnO_4), oxidized with sulfuric acid (5 ml per l of solution). The reaction follows the formula



as a result of which the metallic silver is converted into the water-soluble sulphate (Ag_2SO_4) and is washed out of the emulsion.

The reduction of the negative can be overall and local.

Overall reduction of the negative is necessary in those cases when it is necessary to eliminate slight fog or to eliminate the "contraction" of line elements (for example, in the case of overexposure or poor publisher's original). The reducer is poured over the negative in a uniform thin layer and after 1-10 minutes it is washed off with a jet of water. In case of particular necessity this operation is repeated 2 or 3 times. However, multiple reduction weakens the emulsion noticeably and may cause the negative to be spoiled. If it is necessary to reduce only individual places on the negative, the

reducer is poured in a thin layer only over those places requiring reduction, and washed off with a stream of water after 1-2 minutes.

Intensification

Cases are encountered sometimes when it is necessary to increase the optical density of the light background of the negative (for example, in photography of originals with yellow or gray background, etc). For this purpose one employs intensification.

The negative can be intensified in many ways. A very good method of negative intensification is by means of an intermediate negative. In this case the negative that must be intensified is used to print a diapositive, from which another negative is made by contact printing, using a more contrasty material. A shortcoming of this method is that it requires considerable time and consumption of a considerable amount of photographic material. A method differing in principle from the copy-negative technique are the chemical intensification methods, employing in practice: (1) intensifiers which deposit on the negative a supplementary amount of silver or other substances, increasing the optical density; (2) intensifiers which color the background of the negative with a nonactinic dye thereby increasing its copying density without increasing its visual optical density. Intensifiers of the first group include copper, mercury, chromium, the lesser known quinone-thiosulfate intensifiers and others; the latter group includes the uranium intensifier.

The result of intensification can be characterized by the ratio of the optical density (D) of the background of the negative (in this section we refer everywhere to line negatives) after intensification and the density prior to the intensification, i.e., on the ratio $D_{in}/D_{nominal}$.

In practice we are interested not in optical densities, but in the contrast coefficients (γ) of the image before and after intensification. If γ_{in} denotes the contrast coefficient after intensification of the negative, and γ_{nonin} the contrast coefficient prior to intensification, the result of the intensification (Γ) can be expressed by the ratio

$$\Gamma = \frac{\gamma_{in}}{\gamma_{nonin}}.$$

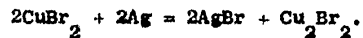
Various intensifiers result in values of Γ from 1.2 (from mercury intensifier) to 3.5 (for uranium intensifier).

By their operating characteristics, one distinguishes 3 types of intensifiers: proportional -- which increase the density (D) of the image in proportion to the initial density, superproportional -- which produce a greater relative intensification of the larger densities, and subproportional, which intensify the lower densities to a relatively greater extent.

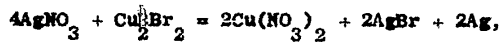
The intensification process, as a rule, occurs in 2 stages, the first consisting of bleaching, whereby the metallic silver is converted into halide and the reaction products are deposited on the silver halide, and the second consisting of blackening, i.e., in the conversion of silver halide into metallic silver and the conversion of the substances that are deposited on the halide silver into opaque compounds.

Let us consider the chemical aspects of the action of certain intensifiers.

Copper Intensifier. To intensify with copper salts one employs cupric bromide (CuBr_2), which is formed in the intensifier by reaction of copper sulfate (CuSO_4) and potassium bromide (KBr). The process can be represented as follows:



Because the metallic silver (Ag) is converted into silver bromide (AgBr), the image becomes white, and hence the term "bleaching." After a short wash the bleached image is blackened in a solution of silver nitrate. The reaction, which follows the formula



produces already 2 molecules of silver bromide for each atom of metallic silver. If the newly-formed layer of silver bromide is developed, the reduced metallic silver increases the optical density of the blackening.

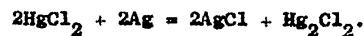
The intensification technique by means of the copper intensifier consists of the following.

1. Thorough washing after fixing. The negative to be intensified should be thoroughly fixed, so as not to leave any grains of silver halide in locations not exposed to the action of light. Washing must also be thorough, so as to eliminate fully from the layers of the emulsion the products of the reaction between the silver bromide and the hypo.
2. The washed plate (or film) is immersed in a tray with copper intensifier (bleach) and left until the dark image becomes clean-white. The tray should be rocked until the negative is bleached. Sometimes one bleaches on a rack in the sink of the photographic

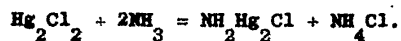
laboratory. In this method there is a useless waste of a large amount of intensifier. By bleaching in a tray it is possible to intensify with the same intensifier 1.5-2 times a larger area of negatives than on a rack.

3. After a short wash, the bleached plate is blackened in a solution of silver nitrate. The blackening, as the bleaching, must be performed by immersing the plate (or film) into a solution of silver nitrate, and not on a rack. Another way is to wash the plate after bleaching and re-develop it in a developer for silver-bromide photographic emulsions. After redevelopment the plate is washed and dried. As a rule, intensification with a copper intensifier gives very good results.

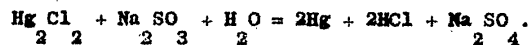
Mercury Intensifier. A sublimate intensifier is employed relatively rarely owing to the poisonous nature of sublimate. Bleaching is in a mixture of a 2% solution of sublimate with 2% of sodium chloride. Here the metallic silver is transformed into the chloride in accordance with the following reaction:



When blackened with an ammonia solution, the chloride compound of the mercury (Hg_2Cl_2) is converted into a complex compound of ammonia, mercury, and chlorine, black in color and consequently increasing the density of the image. The reaction follows the formula



If the blackening is carried out with a sulphite solution (10%) the intensification is produced by precipitation of mercury in accordance with the formula



Finally, blackening can be carried out in the developer, in which case metallic silver and mercury are formed.

Chromium intensifier. The intensifier used is potassium bichromate ($K_2Cr_2O_7$), with hydrochloric acid added to its solution to form the bleach. During the reaction the silver becomes transformed into silver bichromate, and then into silver chloride ($AgCl$) by interaction with the chlorine ions resulting from the presence of hydrochloric acid (HCl) in the solution. The bichromate salt is partly reduced into compounds like Cr_2O_3 or CrO_3 , which are not dissolved in water and are deposited on the silver, thus increasing the optical density of the blackening. The intensity of intensification increases with increased acidity of the solution. However, if the acid content is more than 7-8 mm/l of solution, the intensity of intensification diminishes. No intensification takes place at all if the acid content is 25 ml and more per l of solution.

A negative bleached in a chromium intensifier is blackened in an ordinary developer. Better results are obtained by high speed developers with low sulphite contents.

When working with any intensifier, the process is performed in an illuminated laboratory, so as to be able to observe the course of the bleaching and blackening. If necessary, the intensification of the silver-bromide negative can be repeated.

To obtain good results by intensification the negatives that must be subjected to this operation should be completely fixed, so that no silver halide grains remain in the emulsion. It is also necessary to see to it that the negatives to be intensified have no fog. In the presence of even a light fog in the negative it must be

eliminated before intensification by reduction (for example, by treating the negative with Farmer's reducer).

By reduction or intensification it is possible to correct only slight defects of negatives and this method cannot be used to correct negatives that have been spoiled as a result of disturbances to its production processes. Therefore, it is necessary to pay principal attention to strict observance of the technological process. In the latter case one need not resort to reduction and particularly to intensification.

CHAPTER 5

WET-COLLODION METHOD OF PREPARATION OF NEGATIVES

The wet-collodion method is less convenient than work with dry silver-bromide emulsions. A negative made by the wet-collodion method is more expensive than the silver-bromide one, since it requires considerably larger expenditure of silver nitrate and other expensive materials. Nevertheless, the wet-collodion method is widely used in the publication of maps. For all its shortcomings it has the following important advantages:

- (1) The possibility of obtaining very good background density on the negative, corresponding to the white areas on the original. Up to recently the optical density of the negative background, obtained by the wet-collodion method, has been unsurpassed.
- (2) The possibility of obtaining on the negative a line drawing with sharply blackened edges. The wet-collodion method makes it possible to obtain on the negative a transparent line drawing, which produces sharp contrast with the great optical density of the background.
- (3) The absence of a diffusion halo and reflection halo, and a large resolving power of the emulsion, exceeding considerably the

resolving power of even the most fine-grained dry silver bromide photographic emulsions.

The binding medium in the wet-collodion method is collodion, which represents a solution of colloxylin in alcohol (ethyl) and ether (sulphuric). Colloxylin is a complicated produce obtained by treating cellulose with nitric and sulphuric acids. To obtain photographic collodion the colloxylin is dissolved in equal parts of ethyl alcohol (so-called rectified spirits, C_2H_5OH) and sulphuric ether (C_2H_5)₂. Usually one employs 2% collodion, i.e., a solution containing 2% colloxylin and 49% each of alcohol and ether.

14. Preparation of Collodion Photographic Plate

Collodion in itself is not a light-sensitive material, and becomes light sensitive only after silver halide grains are produced in it. For this purpose one introduces into the collodion solutions of halide salts, which interacts, after further treatment, with silver nitrate and forms such grains. The solutions of silver halide introduced into the collodion are called in practice iodates and the process itself is called iodination of collodion.

The halide compound used in the wet-collodion method should be well soluble in alcohol and in a mixture of alcohol and ether. The most frequently employed are cadmium iodide (CdI_2), ammonia iodide (NH_4I), calcium chloride ($CaCl_2$), and ammonia bromide (NH_4Br).

Depending on what salts have been introduced into the composition of the collodion, crystals of iodide, chloride, or bromide silver are formed in it. Silver chloride, for example, increases the contrast of the image, but reduces the sensitivity of the emulsion and decreases the density of the negative; silver bromide, to the

contrary, increases the sensitivity of the emulsion, but reduces the contrast of the image. Therefore one introduces as a rule various halide compounds into the collodion emulsion, so that their useful properties can be employed and their shortcomings can be compensated for. On the whole the photographic collodion contains 8-12 g/l of various halides salts, and depending on the purpose of the emulsion (line work, halftone work, etc) chloride and bromide compounds amount to 10-30%.

Since the greater part of the salts in the collodion are iodide, forming silver iodide, which cannot be sensitized, it is impossible to change the spectral sensitivity of the collodion emulsion, and therefore it is sensitive only to the blue-violet and ultraviolet portions of the spectrum.

To prepare the light sensitive layer one introduces to the 2% solution of the photographic collodion a definite amount (depending on the purpose of the emulsion and the recipe employed) of silver halides to obtain the iodinated collodion.

The iodinated collodion is not suitable for work immediately after preparation, and acquires the necessary properties only after 2-3 days.

Collodion has a slightly yellow color. The properties of freshly-prepared iodinated collodion (of slightly yellow color) vary, and it cannot ensure constant and reproducible results in operation. After 2-3 days it acquires an orange-yellow color (the color of strong tea), and its properties become stable by that time and it becomes suitable for work. After prolonged storage, iodinated collodion acquires a red color owing to the decomposition of the salt

introduced into it and owing to the separation of free iodine (not bound into chemical compounds) in large quantities. The collodion, which acquired a red color, has no sensitivity and is not suitable for work. Various methods proposed by many authors to correct such collodion (addition of metallic cadmium, ammonia, fresh collodion, etc) cannot be considered satisfactory.

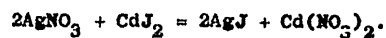
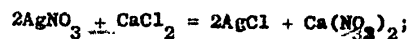
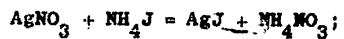
Only chemically pure substances should be used for the preparation of the iodinated collodion; it is necessary to keep the vessels absolutely clean, for even insignificant impurities cause spoilage. It is best to employ for iodination of collodion the so-called "pure for analysis" substances. The vessels must be washed clean, dried, and rinsed in alcohol before using.

The collodion should not contain water. Unfortunately, however, it is so far impossible to obtain completely waterless alcohol and ether. Ether may contain up to 3% water, and alcohol considerably more. It is necessary to see to it that the water content in ether be not more than 3%, and that the strength of the alcohol be not less than 96%. The alcohol and ether should contain no impurities whatever. The use of raw alcohol, denatured alcohol, and other similar alcohol is therefore excluded in the manufacture of photographic collodion.

It is possible to employ in the manufacture of photographic collodion pure film (celluloid base of aerial photographic film, motion picture film, or sound-recording film) instead of celloxylin. It must be borne in mind that celloxylin gives a collodion of higher grade. The worse results are obtained with medical collodion, the constant use of which is not advised and is not recommended in technological instruction.

To make a plate covered with a layer of iodinated collodion sensitive to light, it is immersed in a solution of silver nitrate (AgNO_3). When the plates is immersed, the silver nitrate reacts with the halide salts in the collodion, forming grains of silver halide.

The reactions follow the following schemes:



The sensitization of collodion emulsion must be made in orange light.

A photographic plate made in this manner is used in the same manner as any other plate, and the entire process from the exposure of the plate to the development inclusive should be performed within a very short time, before the photographic emulsion had a chance to dry.

The collodion layer is coated on the glass in a special fixture (rack) which permits uniform distribution of the collodion layer over the surface.

Before coating the collodion, the glass is thoroughly cleaned of all dirt. The edges of the glass are smeared with a solution of latex in benzine, which serves as a binder between the glass and the collodion film, helping it to stay on the glass.

As indicated above, the photographic collodion consists 90% of alcohol and ether, and therefore the collodion should be poured on the glass by the photographer rapidly and firmly, so that the collodion is uniformly distributed over the surface of the glass, until it begins to thicken noticeably. The collodion is poured on the

center of the glass and the latter is gently rocked in different directions, so as to distribute the collodion uniformly over the entire surface. It is important to see to it that no bubbles remain on the surface layer and that the surface reaches everywhere the extreme edge of the glass.

After the layer is distributed over the entire surface of the glass and after the emulsion has thickened, it is immersed in a bath with a 10% solution of silver nitrate (AgNO_3).

When the plate with the coated collodion emulsion is immersed in the silver nitrate bath, it is necessary to see to it that the solution of silver nitrate covers the glass uniformly over the entire surface, for otherwise all the streaks or other defects will unavoidably affect the quality of the finished negative in the form of an uneven background, which will make the subsequent operations considerably more difficult.

The sensitization is finished when the silver solution begins to flow off the surface of the plate uniformly, and the plate steps "growing fat" and assumes a uniform dull-white color.

An aqueous solution of silver nitrate is not in position to penetrate inside the collodion layer. Therefore the substitution reaction, and consequently the formation of the silver halide grains takes place in a very thin surface film of the collodion photographic emulsion. Because of this the sensitivity centers, and then (after the exposure of the plate) also the development centers, are formed directly on the surface of the collodion photographic emulsion under a covering film of a silver-nitrate solution that remains on the plate after it is sensitized in the bath.

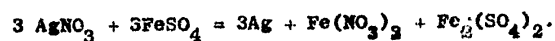
After sensitization, the plate is placed in a holder, which is inserted in the camera for the exposure. The exposed plate is developed immediately.

15. Development and Fixation of Negative

The development of a wet-collodion negative differs from the development of a silver-bromide negative. In the latter case the development was chemical and consisted of reducing to metal the silver in the silver halide grains, distributed over the thickness of the emulsion.

The development of the wet-collodion negatives is physical, since the silver halide is reduced and the visible image is produced by the silver nitrate that remains on the surface of the plate after it is sensitized.

For this purpose one employs ferrous sulfate ($\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$), which interacts with silver nitrate, oxidizes, is converted from the bivalent into the trivalent salt, and reduces the silver nitrate to metal. The reaction can be represented as follows:



The reduction of the metallic silver from the AgNO_3 solution results in a very rapid formation of a supersaturated solution of silver, which begins to crystallize in places where crystals of silver are located. Such places are the particles of the latent image (development centers). If the developer is kept for a long time on the surface of the plate (for example, several minutes), the crystallization of the silver will take place over the entire surface, and this is why the development must be fast, so that the silver settles only in the places exposed to the action of light.

The development is completed when the background of the negative becomes light gray and one can readily distinguish on it the lines, dots, and shading lines of the cartographic drawing. Development usually lasts 20-40 seconds.

To stop the action of the developer it is washed off the plate with a stream of water. This operation should also be carried out very rapidly, so as to remove the developer from the entire surface as simultaneously as possible. Washing usually lasts until the water begins to flow uniformly over the negative, indicating that the traces of the developer have been removed.

Wet-collodion negatives cannot be developed in a tray, for the thin layer of the solution of the silver nitrate can be readily washed off by the developer. The development is therefore carried out on a special fixture, and it is necessary at the same time that the developer poured on the negative remain on it if possible without flowing off; this is accomplished by rocking the plate during the development.

It is important that the developer cover the plate uniformly, otherwise the negative may be spoiled. For this purpose the photographer must pour the developer on the negative with a quick motion along one of its sides. When the solution reaches the opposite side, the negative is so tilted that the solution starts flowing in the opposite direction, and this is done until development is finished.

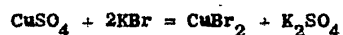
The negative that is developed and washed after development is fixed in a hypo solution to remove the silver halide compounds from the emulsion. This process is carried out the same as the fixation process of silver-bromide negatives, during which the halide salts are

converted by a sequence of complicated chemical reactions into compounds that are easily soluble in water and that are readily washed out and carried away from the light-sensitive emulsion.

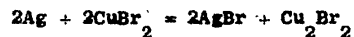
16. Intensification and Reduction of Wet-Collodion Negatives

In photography with dry silver-bromide photographic emulsions the intensification of the negative serves to correct defects resulting from errors in the photographic process. In the wet-collodion method, the intensification is essential, for the layer of the metallic silver obtained as a result of development is very thin and cannot provide the required optical density for the negative background. It is difficult to copy a printed form from a negative with a weak background.

The wet-collodion negatives are intensified in most cases with cupric bromide (CuBr_2), with the latter being formed by interaction between copper sulfate (CuSO_4) and potassium bromide (KBr) that are introduced into the intensifier

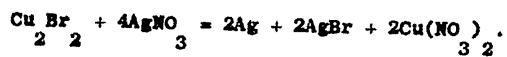


When the negative is immersed in the intensifier solution, the silver that makes up the image reacts with the copper bromide to form as a result silver bromide and cuprous bromide, which are insoluble in water



As a result of this process, the image of the negative becomes white. This is why the process is called bleaching.

The bleached image is blackened with 5% solution of silver nitrate. The silver nitrate does not react with the silver bromide, but only with the cuprous bromide, forming metallic silver, copper nitrate, and silver bromide.



We see that as a result of intensification, as in the case of the intensification of the silver-bromide negative, 2 molecules of silver bromide are added for each atom of silver in the originally developed image, and the image is consequently intensified.

After fixing and before intensifying, the negative should be thoroughly washed, so that the chemical intensification processes take place normally and uniformly over the entire negative. Both the bleaching and the blackening of the negatives up to 70 x 80 cm is performed in trays. If the negatives have larger dimensions these operations can be performed not in the trays, but in racks placed in the trays.

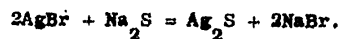
After bleaching and before blackening it is necessary to wash the negative to remove from its surface the excess intensifier, but this wash should be short (within one minute), for prolonged washing will transform the cuprous bromide into cupric bromide, which is soluble in water and which will wash out of the emulsion, and the negative will become reduced.

Since the blackened image contains atoms of silver, the intensification process can be repeated many times. However, the intensification must not be performed more than twice, for each new intensification weakens the bond between the image and the collodion layer (because of the fact that the image consists of finely dispersed powder after the negative is dry). In addition, 2 intensifications are fully sufficient for the production of the necessary optical density of the negative background.

Silver nitrate used for blackening must not have an acid

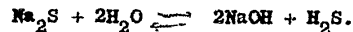
reaction, for this may cause yellow spots and streaks in the negative. The reaction of the silver nitrate solution should be neutral or weakly alkaline (pH = 7-8).

The blackening can be performed with sodium sulfite, which converts the silver bromide into silver sulfite.



Good results can be obtained by combined blackening, in which the first blackening is performed with a solution of AgNO_3 , and the second with sodium sulfite. In this case the second blackening causes the silver bromide to be converted into sulfite and to acquire a dark brown color, thus increasing the optical contrast of the image.

When working with sodium sulfite measures must be taken to remove the hydrogen sulfite formed during the process



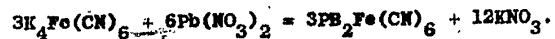
The blackening can also be performed with organic developers, which, since the process is performed under illumination, reduce the grains of the silver halide to metal. Combined blackening can also be used.

To intensify wet-collodion negatives one can use a lead intensifier, composed of lead nitrate ($\text{Pb}(\text{NO}_3)_2$) and potassium ferricyanide ($\text{K}_3\text{Fe}(\text{CN})_6$).

The bleaching is performed in an aqueous solution of lead nitrate and of potassium ferricyanide. The reaction between the initially developed silver of the image and the potassium ferricyanide forms potassium ferrocyanide and silver ferrocyanide. The reaction is as follows:



The silver ferrocyanide (in the form of a white precipitate) is not soluble in water, and therefore remains on the surface of the collodion film. The potassium ferrocyanide, reacting with the lead nitrate, forms lead ferrocyanide and potassium nitrate in accordance with the following formula:

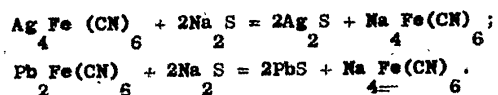


The lead ferrocyanide (in the form of yellow precipitate), like the silver ferrocyanide, is insoluble in water and remains on the surface of the negative. The potassium nitrate is easily dissolved in water and can be readily removed.

The blackening of the bleached image can be performed with sodium sulfite (5% solution).

Before blackening, the bleached image is rinsed in a 10% solution of acetic acid or a 5% solution of hydrochloric acid to remove the reaction products and the excess intensifier.

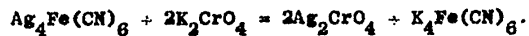
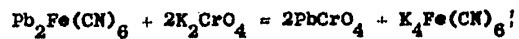
As a result of the reaction between the sodium sulfite on one hand, and the silver ferrocyanide and the lead ferrocyanide on the other, sulfite salts of silver and lead are formed, and owing to their black color they produce in the negative a dense opaque background. The reactions follow the following formulas:



If the blackening is performed not with a sulfite compound, but with a chromate (for example, 10% solution of potassium chromate), then chromate salts of silver and lead are formed instead of the sulfites, namely lead chromate (yellow) and silver chromate

(brownish red), which make the negative background brownish red. Visually this background appears less dense than a black one, but optically, owing to its inactinic color, it is fully adequate to make the negative useful.

The reactions here follow the following formulas:



A shortcoming of this intensifier is that it produces a coarsegrain precipitate.

There are also other methods of intensification and intensifiers, some of which are considered in Section 13.

The reduction of wet-collodion negatives is not only unnecessary, but also not desirable. Nevertheless, owing to errors in the performance of the process or owing to the poor quality of the original, reduction becomes necessary and sometimes useful. In this case the reduction should be slight (removal of a slight fog from the lines of the drawing). To reduce wet-collodion negatives one employs most frequently Farmer's reducer (see Section 13).

After the negative is processed, it is not yet suitable for work. The image formed on its surface, regardless whether it consists of metallic silver or of sulfite and chromate compounds, is a very weak finely-dispersed mass, which can be readily damaged. To strengthen the emulsion of a wet-collodion negative its surface is covered with a layer of protective lacquer.

Negatives made with the wet-collodion method, for all their advantages, have several shortcomings: the surface of the negative

film is weak; cracks appear frequently after some time in individual spots of the surface of the film, and then the film begins to peel. Sometimes this process covers limited parts of the negative, and sometimes it spreads over the entire surface. In either case, the negative must be redone. It is only rarely that it is possible to stop the peeling of the negative without reworking it, but a high grade printing form cannot be obtained from such a negative.

The causes of this serious shortcoming are still far from being known, since very little investigation was done in this direction to date, although the problem deserves greater attention.

From many observations made at the NRKCh, it was established that the shortcoming is observed exclusively in negatives that are subjected to selective retouching, and is almost never observed in negatives not subjected to such treatment. A negative on which the defect appears subsequently, at first does not differ from the remaining. A certain time after retouching, slight cracks appear on the surface of the negative; and with time these increase and branch out, and the surface layer peels off in those places in scales and flakes off upon slightest contact. In all the observed cases, only the upper portion of the blackened region together with the protective cover crack and flake off; the nitrocellulose base remained on the glass without any sign of damage. Ye. N. Spiridonova experimented at the NRKCh to study this phenomenon. Her observations and certain deductions following from them are given below.

Microscopic investigations of the transverse cross-section of the collodion film show that the film consists (in the case of an unretouched negative) of 3 layers; the nitrocellulose collodion base

(the collodion film proper), the dispersed precipitate of metallic silver, and the film formed by the protective lacquer cover. A negative subjected to retouching includes in addition a fourth layer, the layer of the retouching dye [ink]. We thus have a multi layer system the different parts of which vary in their physical and chemical properties (Figure 46).

1. The nitrocellulose collodion base -- the collodion film proper -- is a thin (approximately 0.2 mm) transparent film of nitrocellulose (and of plasticizers if the collodion is made from used photographic film), obtained after the solvents (ether and alcohol) have evaporated from the collodion layer. Since collodion is manufactured at the present time at the map factories exclusively from celluloid obtained by cleaning the emulsion layer off the base of various photographic films, the collodion film remaining on the glass contains in addition to nitrocellulose also a considerable amount of plasticizers (camphors, castor oil, etc), the amount of which reaches 15-20% of the materials used for the preparation of collodion. These additives, which make the collodion film elastic, at the same time reduce its moisture contents, and this affects adversely the sensitization and treatment of the collodion negative. According to the data of the NIKFI, the hygroscopicity of unplaster-cized nitrocellulose is 3%, and that of plastercized one is only 0.6%, i.e., 5 times smaller.

In the preparation of the wet-collodion negative, and particularly after it is dried, the collodion film is not only the medium through which the silver halide grains are distributed, but is also the base, on the surface of which the image is formed and fixed. The greater the hygroscopicity of the collodion layer, the

deeper can the water solution of AgNO_3 penetrate the wet-collodion photographic plate during sensitization, and to the contrary, the lower the hygroscopicity of the layer, the less can the silver nitrate solution penetrate. Naturally, if the plastercized materials used for the manufacture of collodion have a hygroscopicity of only several tenths of a percent, the resultant surface layer of silver halide (principally silver iodide) formed during the sensitization of a wet collodion plate, while perhaps not monomolecular, is at any rate very thin.

2. The dispersed precipitate of metallic silver is formed both during the development time, and also particularly during the intensification of the negative. The development is apparently not only physical, but also chemical. At least in a molecular upper layer, the silver iodide becomes reduced to metal. This process is very fast. The appearance of the silver iodide grains, which act as catalysts, leads to the formation of the image owing to the film of AgNO_3 solution remaining on the negative. Thus, the developed image of a wet-collodion negative can be considered as consisting in part (an insignificant one) of developed iodide grains in the collodion layer, and in part (a greater one) of silver precipitated on the surface of the layer from the AgNO_3 solution.

Intensification of the negative causes a new layer (and sometimes layers) of silver and other materials to grow on top of the developed image and to intensify the image. The net result is a brittle finely-dispersed precipitate, which is weakly bound to the surface layer of the developed image and which has no mechanical strength. As we see, the situation here is opposite to that observed in the silver-bromide emulsions, where the gelatine is a medium

in which the developed silver halide grains are distributed and form an image, and therefore once the negative is dried, it has high mechanical strength.

3. The protective film (lacquer) is a thin film of some sort of hydrophilic colloid (gum arabic, dextrin, etc). It is known that thin films of these materials have no elasticity, are brittle, and are readily damaged. In addition, they react strongly to variations in temperature and humidity of the surrounding medium, and are subject to rather considerable deformations.

Solutions of hydrophilic colloids poured over the intensified wet-collodion negatives penetrate deeply into the brittle intensified precipitate and are bound to it strongly after drying. Thus, the intensified (and even the developed) part of the image is bound more strongly to the protective coating film which serves only as a base for the formation of the image on which the remainder is held weakly, than to the colloid film.

4. The layer of retouching dye is a coarse-grain system, and therefore differs noticeably in its physical and chemical properties from the layers underneath. As is known, the retouching dye consists of particles of some sort of pigment with a binder, which is, in most cases, a solution of one of the hydrophilic colloids. This layer differs from the collodion film in its hydrophilic nature and differs from the protective coating in that it has the coarsely-dispersed structure of the pigment and is considerably more viscous in work.

It follows from the above that the image on a wet-collodion negative is a multilayer system, different parts of which have different

and sometimes even opposing physical-chemical properties. The difference in the physical-chemical properties of the different layers of the image and their unequal reaction to any external influence, are the main causes of the weakness of the surface layer of the image, resulting in the above-mentioned defects of the wet-collodion negatives, frequently encountered in practice.

A microscopic investigation of the transverse sections of the film of the wet-collodion negative shows that the collodion nitrocellulose film of the dried-out negative occupies about 30%, the silver layer of the developed and intensified image about 50%, and the protective-coating layer is less than the thickness of the collodion film. Thus, the layer forming the image comprises half the thickness of the entire system and is contained between 2 thin different films.

What actually causes the cracking and peeling of the surface film of the wet-collodion negative? It was indicated above that most frequently cracking and peeling occur in those negatives which have been retouched and stored for a particularly long time. Probably the cracking is observed because the surface layer of the protective coating has experienced during retouching an uneven stress, and since this layer does not have great elasticity, this uneven stress leads to cracking. Analogous phenomena occur during prolonged storage of the negatives. One can assume that the first to crack is the layer of the retouching dye, which, owing to its strong bond to the layer of the hydrophilic colloid, carried with it the latter, resulting in peeling of the negative. Such an explanation for the cracking of the film and for the peeling of the wet-collodion negative is confirmed in practice.

To prevent cracks and peeling of the image from the negatives it is necessary to replace the wet-collodion method by some other method, such as dry silver-bromide plates. One can recommend for all cases, when line elements are drawn on the same original and when 4 or more elements are printed in different colors, that contact printing be used to duplicate the negatives via an intermediate positive, also obtained by contact from the initial wet-collodion negative. In this case the contact copying can be carried out either with dry silver bromide plates (film is excluded owing to its considerable and uneven linear deformation), or else using one of the methods for silverless preparation of negatives and diapositives using chromated gelatin (selective coloring methods, wash-off relief methods, etc).

When the printing forms were prepared at the NRKCh for the world's atlas, dry silver bromide plates produced at the plant were used, and the wash-off relief method was successfully used in the publication of maps for higher teaching institutions.

Unfortunately, however, this is not always possible. It is therefore necessary if not to be completely free of this shortcoming of wet-collodion negatives, at least to reduce its occurrence. For this purpose it would be necessary to prepare collodion from colloxylin and not from photographic film, since the hygroscopicity of the unplasticized colloxylin is several times greater than that of the plasticized one, and this means that the aqueous solutions of AgNO_3 and of other reagents, with which the negative is treated, can penetrate more deeply into the wet-collodion film, where they can reduce and precipitate more silver, thereby contributing to a better fixing of the developed and intensified image.

Another way is to choose a protective coating that has enough elasticity to compensate for the effect of the uneven stresses experienced by the layer during the use and processing of the negative. Of all the inexpensive materials tested at the NRKCh at the present time, the best results were obtained with the coating of hydrolized gelatine suggested by Ye. N. Spiridonova. By introducing alum into the gelatine it is possible to make a stronger cover, since hardened colloids are more elastic than unhardened ones.

CHAPTER 6

SCREEN PHOTOGRAPHY

17. General Information

The planographic printing form cannot reproduce halftone images (images with gradual transition from dark areas of the drawing to light ones in the presence of many intermediate shades). To maintain halftones on the print it is essential that there be little ink on the light areas of the image, more ink in the transition areas, and a maximum amount in the darkest areas. On the planographic printing form, each element of the image contains a single layer of ink, and various printing elements can differ only in size, i.e., quantitatively. The planographic printing form is consequently a line form, i.e., a form capable of reproducing by printing drawings consisting of line elements (lines, dots, etc). In the publication of maps it is necessary to reproduce halftone images of the relief, prepared by wash-off methods and of other halftone maps (for example, in classroom atlases).

In order to reproduce such an image in the print it must be transformed into an image consisting of individual line elements,

but producing on the print an impression of a halftone element with gradual transition from light to shadow. To break up a solid halftone image into individual line elements one employs screen photography. Use is made here of the property of the human eye of distinguishing individual elements only if the distances between them are not less than a certain value.

Many investigations have established that the human eye can distinguish between individual elements provided the distance between elements is related to the distance from the elements to the eye as $1/1500$, i.e., provided the ration $AB/DC = 1/1500$ (Figure 47).

To reproduce a wash rendering of the relief on maps of the table type, which are viewed at an average distance of 25 cm (normal vision), the distance between individual elements of the image must be less than or equal to 0.165 mm if the image is to be perceived as solid

$$AB \leq 0.00066 \times 25 \text{ mm} = 0.165 \text{ mm}.$$

For a wall classroom map, which is viewed by the students or teacher from a distance of approximately 1 m, the distance between individual elements can be equal to or less than 0.66 mm

$$AB \leq 0.00066 \times 1000 \text{ mm} = 0.66 \text{ mm}.$$

For a student who views the map from the school desk, i.e., at a distance of approximately 5 mm, the distance between individual elements of the image must not exceed 3.3 mm

$$AB \leq 0.00066 \times 5000 \text{ mm} = 3.3 \text{ mm}.$$

The halftone image is broken up into individual line elements by a special optical device, a screen. The screen represents a grid of intersecting mutually perpendicular opaque lines, which are placed in front of the light-sensitive emulsion of the photographic plate in the path of the rays reflected from the photographed object. The grid,

being projected on the light-sensitive emulsion (i.e., blocking part of the rays reflected by the original), breaks up the solid image into individual elements. In this case wherever a large amount of light (reflected by the brighter parts of the original) passes through the transparent elements of the grid, the blackening will be over a greater area, i.e., a larger size black dot will form, and where less light passes, the blackening, and consequently also the area of the dot, will be less. If a diapositive is made from such a negative, there will be more dots in places corresponding to the dark portions of the original, and these dots will be located closer to each other owing to the small gaps between them. In places corresponding to bright parts of the original, the dots will be very small, and the distances between them will be considerably greater. Thus, an impression of a dark tone will be formed in the former case, and that of a bright tone will be formed in the latter case.

The screens used in screen photography comprise 2 plates of glass, on which black parallel lines are drawn, glued to each other. The plates are so glued, that the lines intersect at right angles (Figure 48).

18. Theory of Formation of the Screen Image and Calculation of Screen Factors

The formation of the screen image is shown schematically in Figure 49, where D'D' is the diaphragm, SS is the screen (more accurately, the plane of the grid of the screen), and PP the light sensitive surface of the photographic plate (dull surface of the ground glass).

As can be seen from the diagram, photography through the screen produces on the light sensitive emulsion points which the light does not reach at all (T_1 , T_2 , etc), and points in which all the light passing through the objective passes (C_1 , C_2 , etc). Between these, one obtains a gradual transition region from full illumination to full darkness, i.e, the halftone region. This indeed is the basis for the formation of the halftone image by points of different dimensions on the photographed negative.

If the original is a uniform white (or gray) surface, then if it is photographed through the screen there are formed on the negative many identical dots, equally spaced from each other, since the entire surface of the original reflects an equal amount of light at all points. If a halftone image is photographed, different parts of the original reflect different quantities of light. In some places (the brightest ones) this is enough for the formation of a large area of blackening, in other places there is so little light, that it can blacken only a very small area. Therefore, dots of different sizes are produced on the various parts of the negative.

Figure 50 gives the magnified image of a gradual transition from light to shadow, obtained with the aid of screen photography.

If the distance between the light-sensitive emulsion and the screen (P_1 and P_2 on Figure 49) is reduced, the dimensions of the screen dots will decrease, and if the emulsion is in close contact with the screen one obtains a copy of the latter. To the contrary, if the distance between the light-sensitive emulsion and the screen is increased, the dimensions of the dots will increase and at a certain distance the points will merge together into a solid halftone.

The dimensions of the screen dots, which are of great significance for correct reproduction of a halftone image with the aid of screen photography, depend not only on the distances in the screen or between the screen and the emulsion, but also on another factor. Increasing the diameter of the diaphragm increases the size of the dots; increasing the distance from the light sensitive emulsion to the objective (extension of the camera) reduces the dimensions of the dots, and vice versa (Figure 51). All these elements are connected by relationship, which can be expressed mathematically. Let us consider for this purpose the triangle OT_3d_1 and $OT_3d'_1$ (Figure 49). From the similarity of these triangles one can write

$$\frac{OT_3}{O'T_3} = \frac{d_1}{d'_1}, \quad \frac{1}{OT_3} = \frac{d'_1}{d_1}.$$

OT_3 represents the extension of the camera, denoted by f ; $O'T_3$ is the screen distance, denoted by r ; d_1 is the diameter of the diaphragm D ; d'_1 is the side of the screen cell a . One can therefore write:

$$\frac{f}{r} = \frac{D}{a}; \quad \frac{D}{f} = \frac{a}{r}.$$

The quantities f (camera extension), D (diameter of effective aperture of objective), r (distance from the grid of the screen to the light-sensitive emulsion -- the screen distance) and a (the side of the screen cell) are called the screen-photography factors, or the screen factors.

For a long time the best mutual placement of the screen and light-sensitive emulsion was determined on the ground glass, observing the dimensions and character of the dots with a magnifying glass while moving the screen back and forth to determine the optimum conditions for the reproduction of any one halftone image. This

naturally required high skill and great practical experience on the part of the photographer.

But it is clear from the above that for each screen photograph there can be only one relationship between the screen factors r , D , a , and f , and consequently these elements can be established purely theoretically, and this means that screen photography, which formerly required the employment of people with great skill, can now be performed by any photographer. Experience has shown that the most experienced photographers, who can obtain empirically good results, work under conditions close to those given by calculation [17].

It follows from the expression $D/f = a/r$ that

$$a = Dr/f; \quad D = af/r; \quad r = af/D.$$

There is no need to determine the extension of the camera f , for it depends exclusively on the scale of photography and on the focal distance of the objective employed ($f = F(n + 1)$). The value of a is also determined by relatively simple calculation, for the ruling of the screen is generally known beforehand. If the number of screen lines per cm is denoted by λ , then the quantity a (side of the screen cell) can be determined in mm from the expression

$$a = 10/2\lambda = 5/\lambda$$

If, for example, a screen with 40 lines/cm is used, a will be

$$a = 5/40 = 0.125 \text{ mm}$$

For a screen with 60 lines, a turns out to be 0.083 mm etc.

Given below are the cell dimensions of screens of various rulings.

Ruling of screen	24	34	40	48	54	60
Value of a	0.208	0.147	0.125	0.104	0.093	0.083

For each photograph it becomes necessary to determine the values of the 2 remaining screen factors, i.e., D (diaphragm) and r (distance from the screen to the light-sensitive emulsion).

Since the first factors are always specified beforehand, D and r can readily be expressed in terms of f and a. For example, for the case when the photography is on a scale 1:3 in a camera with an objective having F = 90 cm through a screen with 40 lines/cm, the values of D and r can be determined from the following equations:

$$D = af/r = 2070 \times 0.125/r = 258.8/r \text{ mm};$$

$$r = af/D = 258.8/D \text{ mm}.$$

To use the above equations to determine actual values of D and r, it is necessary to specify beforehand the value of one of each, in practice the value of r, and to determine the value of D from this condition.

Most workers suggest the use of $r = 64a$ or, as indicated in the instructions, $r = f/64$, which is the same, for $D = af/r$, but since $r = 64a$, we have $af/r = f/64$.

If the quantity is substituted into the expression given above, we get

$$D = 258.8/r = 258.8/64 \times 0.125 = 258.8/8 = 32.4 \text{ mm}.$$

As in the case of other screen factors, the values of r are best calculated beforehand and tabulated, to avoid calculation every time. Given below are the distances from the screen to the light-sensitive emulsion (in mm) for the cases most frequently encountered in practice.

Screen ruling	24	34	40	48	54	60
$r = 64a$	13.3	9.4	8.0	6.6	6.0	5.3

Thus, the values of the diaphragm (D) remain to be determined. These are given in Table 13.

We insert the value of r , expressed in terms of a , into the expression $D = af/r$ and obtain

$$D = af/r = af/a \cdot 64 = f/64,$$

It is evident from this equation that the diaphragm value depends only on the scale of the photograph and on the focal distance of the objective employed and is independent of the ruling of the screen. In other words, it is the same for a screen of any ruling provided the camera extension is constant.

With the data given in Table 13 it is possible to perform screen photography without any calculations at all. But Table 13, in the form it is given, cannot be used, for it is practically impossible to set the diaphragm in mm and these values must be converted into values showing the relative aperture of the objective. For this purpose one can employ the following data.

Focal distance of objective	Scale of photograph		
	0.5-0.6	0.7-1.3	1.4-2.0
450-1,200	45	32	22

Approximate values are given here, but they are quite suitable for most cases and ensure normal reproduction of the gradation scale of the halftone original.

Thus, for each case of screen photography, any photographer can determine readily all the screen factors and to compile a table of the values for convenience.

TABLE 13

Scale of photograph

Focal distance of objective F (mm)	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
450	10.5	11.2	11.9	12.6	13.3	14.0	14.7	15.4	16.1	16.8	17.6	18.3	19.0	19.7	20.4	21.1
600	14.1	15.1	16.0	17.0	17.9	18.9	19.8	20.8	21.7	22.7	23.6	24.6	25.5	26.5	27.4	28.4
750	17.7	18.8	20.0	21.2	22.4	23.6	24.7	25.9	27.1	28.3	29.5	30.6	31.8	33.0	34.2	35.4
900	21.2	22.6	24.0	25.4	26.8	28.3	29.7	31.1	32.5	33.9	35.3	36.7	38.2	39.6	41.0	42.4
1,200	28.3	30.1	32.0	33.9	35.8	37.7	39.6	41.4	43.3	45.2	47.1	49.0	50.9	52.8	54.6	56.5

Let us assume that it is necessary to photograph the original of a wash rendering of the relief in a 1:1 scale (natural size) of a map sheet 70 x 80 cm through a 40-line screen. For this case it is necessary to use an objective with a focal distance $F = 90$ cm.

Using these data, it is possible to select from the tables given above, all the data for the photography, namely: $f = 1,800$; $a = 0.15$; $r = 8.0$, and $D = 32$. It is then possible to compile the following table for this particular job:

Distance from screen to ob- jective	Camera extension f	Size of cell of screen, a	Distance of screen r	Diaphragm D
1800	1800	0.125	8.0	32

Experience in screen photography shows, however, that the calculations given above are not satisfactory. This is due principally to the following causes. In those places on the print, corresponding to places on the original that had no drawing at all, there are points that should not be there. In places corresponding to the blackest places of the original, there are also points, even though they are not necessary. Consequently, this results in some reduction in the contrast of the original: the dark places are reproduced somewhat brighter, and the bright spaces somewhat darker than on the original.

This explains the recommendations given in the technological instruction of the GUCK on screen photography, namely that the original of the wash rendering of the relief should be made with higher contrast than required on the print.

In addition, the effect of the diffraction of light and the diffuse halo leads to an increase in the dots and also disturbs the gradation scale.

The reproduction of the gradation scale of the original can be improved by introducing into the theoretical equation for the screen factors special correction coefficients, with which it is possible to eliminate the effect of diffraction and of the diffuse halo.

Let us take the equation $D = af/r$

To reduce the screen dots, it is necessary to reduce the value of D (diameter of the diaphragm), and for this purpose the coefficient K should be less than unity, then $D = af/r K$, if we take K greater than unity, then $D = af/rK$

But even in this case it is impossible in practice to retain the exact gradation scale of the original on the print. The most favorable results are obtained by photography with 2 diaphragms, i.e., photography of 2 values of the coefficient K . Many investigations were carried out for relief printing (zincography), but they can be used also for planographic (including offset) printing.

Without giving all the theoretical calculations and arguments here, let us indicate the following premises confirmed by practice.

At small values of the coefficient K (i.e., at large values of D) the resultant negative is more contrasty, but the shadows are less developed. To the contrary, at large values of K the negative has better developed shadows, but less contrast.

From this we can conclude that in the case of 2 diaphragms (2 values of K) it is possible to obtain a negative that reproduces the gradation scale of the original with sufficient accuracy.

The values of the 2 diaphragms are not arbitrary. Many authors (V. V. Pus'kov, S. P. Miklashevskiy, and others) recommend that the diaphragm be chosen on the basis of values of K ranging from 1 to 2 for the small diaphragm, and from 0.5 to 0.75 for the large diaphragm, depending on the photographic emulsion used. In any case, most authors believe that the value of K for the 2 sizes of diaphragms should be chosen with a ratio 1:2.

In particular, S. P. Miklashevskiy recommends the use of $K = 1$ for the large diaphragm, and $K = 0.5$ for the small one.

The GUGK instructions recommend the diaphragm size to be based on $f/48$ and $f/96$. Experimental photographs of wash relief originals, made at the Publishing Laboratory of the Experimental Graphic Division of the Scientific-Editorial Map Compiling Section under the leadership of V. M. Varzugin, indeed, gave the best results at diaphragms $f/48$ and $f/96$.

In practice exposure on white paper is frequently employed. For this purpose, the original is first exposed through the screen and then covered with white paper and an additional exposure is made at a very small diaphragm and short exposure. This procedure is usually explained by stating that exposing the paper produces required number of dots in the shadows of the image, and the additional dot density obtained in the bright portions does not produce any adverse effect; this cannot be considered correct. Theoretical calculations show, and the practice of screen photo-reproduction work

confirms it, that additional exposure "with paper" disturbs somewhat the gradation scale of the original. Although it helps the formation of dots in the deepest shadows, it simultaneously distorts the character of the original in the bright and middle halftones, and these elements are indeed the important ones in the reproduction of a relief plate rendered by wash methods. In addition, exposure "with paper" reduces the overall contrast of the negative compared with the original. This measure can be therefore used only in exceptional cases.

It is the practice of certain enterprises, particularly NRKCh, to employ a simplified indirect method of reproducing wash drawings and gray-scale originals for the printing of various drawings, for example, in classroom atlases. This measure consists of first making a halftone negative from the original, then retouching its white field, without touching the drawing at all. A diapositive is made by transmitting light through the retouched negative and through a screen. The diapositive is used to print by contact a negative which serves for the preparation of the printing plate.

This measure resulted in a copy that is sufficiently close to the original.

Cases are encountered, when the screen dimensions do not permit photography of the total original. In these cases the original is photographed in parts, and combination copying is used to obtain the printed plate, which contains the entire image.

At the NRKCh the original is photographed in such cases as a whole, but reduced to a smaller scale and through a finer screen. A positive is then made out of this negative (either by projection

or by contact printing), and the positive is photographed by transmitted light to obtain a negative in the required size for the production of the plates. An indirect method can also be employed: the halftone negative is photographed (in natural scale or reduced) by projection, photography through a screen results in a screen diapositive, and the latter is also projected to obtain a working negative at the scale required by the publishing house for the copying of the plate.

The above technological variants are qualitatively inferior to the direct screen method, but give higher quality compared with combination and multiple copying.

One of the measures used widely in the cartographic industry for the reproduction of a relief prepared by the wax method is a 2nd colored printing method called "duplex." One color (usually less intense) is used here to print the general image ("lining"), and the other (usually most intense color) is used to print only that part of the image, which should produce deep shadows, for example, shaded slopes etc ("strokes"). As can be seen, it is necessary to obtain 2 negatives, one of which would reproduce normally the gradation scale of the original. (Many projection workers think that this negative should be "softer," i.e., more monotonic compared with the original. This opinion is wrong.) And another a more contrasty one, which is necessary to retain only the drawing corresponding to the deepest shadows and to dark halftones.

Such images can be obtained on the negative by calculation, and their required qualities can be obtained by varying the dimensions of the diaphragms and of the exposures.

Frequently one employs exposures with the screen moved back

instead of exposing with white paper. In this case after exposing with the 2 diaphragms the screen is moved away from the light sensitive layer (without removing the holder from the camera) at a maximum possible distance, and a third short exposure is given. Here one obtains the same result as when exposing with white paper, but since a halftone original is exposed instead of white paper, the different parts of the image (on the negative) receive proportional amounts of light and the overall gradation scale of the original is distorted to a considerably less extent.

By way of example, let us relate the conditions under which a wash relief of a fragment of a map "Germany and Austria" for higher learning institutions was photographed at the publishing laboratory of the MRKCh by V. M. Varzugin, who obtained favorable results. The photography was on a 1:1 scale (natural size) using an Apo-Tessar lens with a focal distance 90 cm, through a screen with 40 lines/cm, with illumination with 4 PRK-7 lights; the material used was dry silver-bromide plates, prepared at the MRKCh; the developer was KT-1 (TsNIIGAik). The quality of the negative was visually estimated by comparison, using a 9-field scale attached to the original.

Favorable results were obtained for diaphragm values (relative apertures, indicated on the ring): $D = 45$, exposure 12 minutes; $D = 22$, exposure 4 minutes, and $D = 11$ (with screen moved back), exposure 45 seconds.

Another method of reproducing wash relief drawings, in particular for schoolroom maps, is used at the MRKCh. A screened and halftone negative are made of the original at a single setting of the camera. The halftone negative then serves as a mask for the screen negative during copying. It is thus possible to improve somewhat the

reproduction of the gradation scale of the original and to compensate to a certain extent for the shortcomings of the screen negative.

This measure, however, cannot be recommended for extensive use because it is necessary to work with film which is subject to considerable linear deformation.

19. Techniques of Screen Reproduction

The photography of a halftone original through a screen requires a special precision in work, the success of which depends on the careful performance of each manufacturing operation.

Screen photography consists of the following operations:

- (1) mounting the original on the screen;
- (2) calculation and setting of the screen factors;
- (3) setting the lighting fixtures and adjustment of the illumination of the original;
- (4) determination of the exposure of an end exposure of the original;
- (5) development and all subsequent processes of preparation and processing of negatives.

The original is generally mounted on the screen the same as in ordinary photography. In those cases when a rectangular (for example, square) screen is used in lieu of a round one for multicolor screen reproduction (for example, in the reproduction of wash drawings with 2 colors), it becomes necessary to rotate the original.

Many devices are available for rotation of the originals such that the angle of rotation can be determined. In map manufacture, however, it is seldom necessary to produce screen reproductions for more than 2 colors from a single original, and it is therefore not

essential that the exact angle of rotation be maintained. It is necessary to see merely that the angle is large enough to avoid "moire" effects.

It is most convenient to rotate the original on the screen by approximately $25-30^{\circ}$ to the right and to the left of the vertical axis.

Calculation and Setting of Screen Factors. The calculation was discussed above. The setting of all the screen factors should be carried out with maximum precision.

First it is necessary to adjust the camera (see Section 10); this adjustment does not differ at all from the adjustment used for any other photography (without screens). At the same time one of the screen factors f (denoted by the letter b in Table 4) is established. After this, placing the screen in the screen holder, it is located at an exact distance r from the ground surface of the ground glass; the value of r is taken from the table compiled for the actual case of photography. Here it is necessary to bear in mind that r is the distance from the ground glass (or from the light-sensitive emulsion) to the lines of the screen and consequently, it is necessary to take into account the thickness of the glass of the screen, which can be determined as half the total thickness of the screen.

Before setting the position of the screen, it is necessary to check the screen holder and if necessary to correct its scale, which either may turn out to be not in mm, or else may be inaccurate for various reasons. The technique for checking and marking the scale indices is described in the technological instructions of the GUGK on photographic operations.

After the existing scale is checked or after a new scale is drawn, the screen is set at a distance r from the ground glass (light sensitive emulsion). The last operation is to set the diaphragm of the objective.

After all the screen factors have been fully set, the original is illuminated and a magnifier is used to check the quality of the image carefully on the ground glass. When checking the quality of the image it is necessary to use alternately both diaphragms (if photography with 2 diaphragms is used), for this makes it possible to gain beforehand an overall picture of what will be obtained on the negative.

Setting the Lighting Fixtures and Adjustment of the Illumination of the Original. The illumination of the original is particularly important in screen photography. While in line photography any irregularity in the illumination involves merely the danger of the background density becoming different in different parts of the negative, but does not affect as a rule the nature of the illustration, in screen reproduction uneven illumination of the original may lead (and does lead in practice) to a considerable distortion of the halftone image, particularly in the halftones.

The setting of the lights and the adjustment of the illumination of the original are carried in the same way as in any photographic process. It is necessary only that the original be illuminated as uniformly as possible and that there be no reflections from the glass of the screen.

Even a slight unevenness in the illumination of the original reduces the quality of the negative and makes it impossible to obtain

a high grade printed plate from it by copying. In most cases encountered at the MRKCh this shortcoming manifests itself in the original being more illuminated at the edges than in the center. As a result the center of the negative appears to be "open" and the edges "contracted."

Determination of Exposure Time and Exposure of the Original.

The length of the exposure is of great importance in photography, particularly when photographing through a screen. Depending on the actual photographing conditions (character and intensity of the source of light, character and light-sensitivity of the photographic material, etc) the exposure may fluctuate over a considerable range. It is therefore established in the enterprise by test photographs.

When establishing the exposure time, it is necessary to take into account that it is better to have a slight overexposure than an underexposure, for in the latter case it is impossible to correct the negative, while in the former case the negative can be reduced.

In the case of photography with 2 fundamental diaphragms and exposure "with paper" or with the screen moved away, the correct ratio of exposures is of substantial importance. The ratios of the exposures with 2 basic diaphragms (shadow and light) depends on the interval of the original, representing the difference in the optical densities of the darkest and the lightest elements of the drawing. Thus, an original containing drawing elements that are very light and very dark will have a greater range than originals having drawing elements which contain for example, very bright spots, but do not have any spots that are too dark. Assume that the optical density of the brightest place in the original $D_{\min}$ is 0,5, and that

of the darkest one $D_{\max}$ is 1.6. The range of the original will be in this case 1.1 ($D_{\max} - D_{\min} = 1.6 - 0.5 = 1.1$). If originals are subdivided into groups in accordance with their ranges, the following data can be used to establish the exposure with the second (small) diaphragm:

Range of original											
$D_{\max} - D_{\min}$	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	
Relative exposure											
with small diaphragm	4	5	7	10	12	13	15	18	20	25	

The exposure with the large diaphragm, determined experimentally, is taken to be unity.

The increase in the relative exposure with the second (small) diaphragm can be explained as follows: the greater the intervals of the original, the more light is required to produce the shadows, which become relatively darker.

According to the requirements contained in the instructions [3], the exposure time required when exposure "with paper" is used should be approximately 10% of the basic exposure. The same holds also for photography with the screen moved back.

The correctness of the exposure, experimentally determined, is best checked against standard negatives (see instruction) or against a step scale, attached to the original and photographed together with it.

It is particularly difficult to choose the correct exposures in the photography of originals of wash renderings of the relief for reproduction by the "duplex" method. It must be borne in mind here that the exposure must ensure that the "strokes" on the negative

(contour) should contain small dots in the shadow region or should have no dots at all, while in the dark halftones the presence of dots is essential. Spaces between the dots and lights should be small, they may even be "contracted," but in the bright halftones these spaces must be open. All the details of the image must be seen on the negatives [3]. The negative for the "lining" (tone) should reproduce normally the drawing of the original, as was already indicated above. The choice of exposure therefore requires a certain amount of experience.

CHAPTER 7

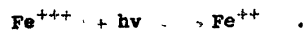
LIGHT SENSITIVE EMULSIONS BASED ON IRON SALTS

Light sensitive layers containing iron salts are extensively used in map publishing processes and in their compilation and planning.

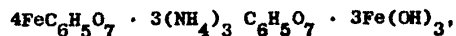
20. Preparation of Blue Copies on Metal ("Phantom Outline") and on Paper ("Blueprints")

It has been long known that certain iron oxide compounds become light sensitive under certain conditions. The most widely used are iron racemate, oxalate, and particularly citrate.

The light sensitivity of iron salts is based on the fact that light converts ferric salts into ferrous salts, changing them from trivalent into bivalent

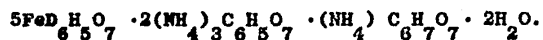


As was already indicated, citric salts of iron are used mostly, and primarily the bicitric salts of ferric oxide and ammonium -- ammonium iron citrate, which is used in the form of a brown or green salt. The brown salt is a base salt having the following composition [7].



Page

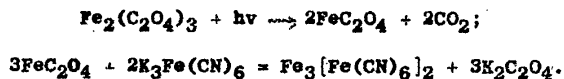
and the green one



The spectral sensitivity of the above salts extends mostly toward the short-wave part of the spectrum (ranging from 475 to 200 millimicrons for the green and 214 millimicrons for the brown citrate of ammonium ferric citrate, with maxima at 375 for the former and 382 millimicrons for the latter) [7].

When Fe^{+3} is converted into Fe^{+2} , in connection with the change in the color of the salt, one obtains a little-noticed image, which must be intensified. In addition, such an image must be fixed the same as it is necessary to fix an image obtained with a photographic plate. The compounds reacting with the bivalent and trivalent salts of iron, making it possible to obtain one or the other, are potassium ferricyanide ($\text{K}_3\text{Fe}(\text{CN})_6$) and potassium ferrocyanide ($\text{K}_4\text{Fe}(\text{CN})_6$). The potassium ferricyanide is a good reagent for ferrous iron salts, and the potassium ferrocyanide is good for ferric salts.

Thus, for example, if iron oxalate is subjected to the action of light and processed by potassium ferricyanide, we get



The ferricyanide salt formed thereby ($\text{Fe}_3[\text{Fe}(\text{CN})_6]_2$) is blue in color, and since it is insoluble in water, it is precipitated and thus forms the image.

Analogous chemical transformations can occur when ferric ammonium citrate is used.

It is clear from above that an image can be obtained in 2 manners: by carrying out the process in 2 stages (first exposure, second treatment with potassium ferricyanide) and by simultaneous performance of the process, when the light-sensitive compound is made directly of citrate of ammonium and iron and of potassium ferricyanide. In the second case the light will produce the chemical transformation in the emulsion as in the former case, and consequently, the same results are obtained, even though technically the process is shortened.

Both methods are used in practice. It is more advantageous (particularly when working with metal) to use the second method, although the first offers a certain advantage, namely, that when the exposed copy is processed with potassium ferricyanide, the drawing obtained is immediately sufficiently noticeable and requires no further intensification, while in the second method the drawing must be intensified (for example, in the preparation of the "phantom outline").

Various enterprises use various methods for the production of images and employ light-sensitive emulsions with ferric oxide salts (they are customarily called not quite accurately, "cyanotype" or "ferroprussiate"). A particularly great variety is in the formulas used for the compounds used for the purpose. A slight but very interesting investigation, carried out in the experimental laboratory of the NRKCh (Ye. M. Spiridonova and M. G. Finger) has made it possible to establish that in most formulas the choice of individual reagents is haphazard and their ratio is quite arbitrary. By way of example let us consider several formulas (Table 14).

TABLE 14

Reagents contained in light-sensitive solution	Formula No 1	Formula No 2	Formula No 3
First stock solution			
Ammonium iron citrate	50 g	30 g	75 g
Citric acid	90 ml of 50% solution	-	60 g
Oxalic acid	-	14 g	-
25% ammonia	20 ml	20 ml	22.5 ml
Water	100 ml	100 ml	90 ml
Second stock solution			
Potassium ferricyanide	10 g	16 g	2 g
Water	100 ml	150 ml	100 ml
Recommended ratio of first to second solution	1:1	2:1	3-5

In spite of the lack of agreement between the compositions of the above light-sensitive solutions, all give favorable results. This circumstance indicates that it is possible to vary the quantities of components contained in the light-sensitive emulsions based on ferric oxide salts. At the same time this also indicates the need for developing better founded and economical formulas for the compounds.

The above-mentioned investigation by Ye. N. Spiridonova and M. G. Finger has made it possible to solve correctly this problem. First, excessive components were eliminated from the composition of the light-sensitive solution. Next, the quantitative relationships between the components were chosen on a molar basis instead of haphazardly.

In this case the most economic and best founded light-sensitive emulsion was found to have the following composition.

First stock solution:

Ammonium iron citrate	12.5 g
Citric acid	5 g
Oxalic acid	2.5 g
Water	100 ml

Second stock solution:

Potassium ferricyanide	4 g
Water	100 ml

The first and second solutions are mixed in a ratio of 1:1.

This solution was checked many times and gave good results.

To obtain a blue image on an aluminum plate using a light

sensitive emulsion based on ferric oxide, the following technological operation must be performed:

- (1) preparation of the plate;
- (2) coating the plate with the light-sensitive emulsion and its drying;
- (3) exposure;
- (4) intensification and fixing of the drawing on the plate;
- (5) preparation of the obtained image for further operations.

Preparation of the Plate. The aluminum plate is immersed for 2-3 minutes in 1% solution of potassium permanganate. It is then thoroughly washed with a stream of water.

Coating the Light-Sensitive Emulsion on the Plate and its Drying. Before coating the light-sensitive emulsion, the wet plate must first be wiped with a cotton pad, to remove excess moisture.

The light sensitive emulsion can be coated using one of the following methods.

1. The emulsion is placed on the plate in a centrifuge by rotation, thus insuring uniform covering of the plate by the light sensitive emulsion. This method, however, requires more solution than any other method. When the centrifuge is rotated at a speed of 40-45 rpm, the solution is poured on in a thin stream, starting with the center of the plate and leading the stream to the edge. Sometimes (if the grain of the plate is particularly thick), the stream is returned to the center rapidly after it reaches the edge. The plate is left in the centrifuge until the emulsion is completely dry. The emulsion is dried at the same speed of the centrifuge, with heaters turned on.

2. The emulsion is coated on the plate manually, and then equalized and dried in a centrifuge. The plate is held in hand and the light-sensitive solution is poured on it; the plate is then uniformly rocked so as to distribute the solution in all sides. The plate with the light-sensitive emulsion coated on it is then placed in the centrifuge, which is rotated at 40-50 rpm and in which the heaters are turned on; this equalizes the emulsion and dries it. Much less light-sensitive solution is consumed in this method.

3. The light-sensitive emulsion is dabbed on the plate with a pad, soaked in the light-sensitive solution; the plate is coated in 2 mutually-perpendicular directions, the same as when the protective colloid (dextrin) is used to cover the printing form. It is necessary to see to it here that the layer is coated on the plate uniformly and that its thickness be as even as possible. The drying is also performed in the centrifuge. This method of coating the light-sensitive emulsion gives a considerable economy in material consumption, but requires a certain skill on the part of the copying operator.

4. The light sensitive emulsion is coated on the plate with a rubber or mastic roller. The plate is placed on a tray and a small amount of solution is poured over it and spread with a roller until the emulsion becomes dense and sticky. The rolling is then stopped and the plate with the coated emulsion is placed in the centrifuge with heater turned on .

The drying in the centrifuge lasts 8-12 minutes. After drying, before the image is copied on the plate, it is necessary that the plate be cooled and become seasoned in the shop air, so

that the emulsion layer of the negative (or the layer of dye) does not adhere to the light-sensitive emulsion coated on the plate.

Exposure. The plate with the coated and dried light-sensitive emulsion is placed in a copying frame with the emulsion upward. The emulsion side of the negative is placed on the plate and the exposure is made.

The duration of the exposure depends on many factors, and it is therefore best to determine under the actual conditions experimentally. If the light source is a PRK-7 quartz lamp and if the distance from the light source to the plate is 100-110 cm, the exposure used at the NRKCh fluctuates from 12-15 minutes.

The intensification and fixing of the drawing on the plate. The image obtained after exposure does not have enough intensity, and must therefore be intensified.

The image is intensified by immersing the plate for 1-2 minutes in a tray with acid. Nitric (HNO_3) and hydrochloric (HCl) are used at the NRKCh, with the best results obtained with a mixture of these 2 acids at a ratio 2:1, with a total content of 30 ml of acid per liter of water. Such a recipe was chosen because treating the copies with nitric acid alone causes the drawing to have an intense blue color, while hydrochloric acid produces an azure color. Using a mixture of the 2 acids gives a drawing with a blue-azure color, very convenient for work.

After intensification, the form is washed with a jet of water, which dissolves the ferric oxide salts that have not been subjected to the action of light and removes them from the plate, and this fixes the resultant image.

Tests have shown that an image produced in this manner adheres strongly to the plate, and consequently the latter can be washed with a strong stream of water, slightly (without pressure) rubbing it with a cotton pad.

Before turning the washed and dried plate for engraving work, the plate must be suitably treated.

Preparation of the Obtained Image for Further Operations.

The preparation consists of treating the plate with an etching compound consisting of a solution of hydrophylic colloid and an electrolyte (for example, dextrin and phosphoric acid). The treated plate is coated with a thin layer of starch before turning it over to the engraver.

The light sensitive compound is prepared of 2 individual stock solutions, which are then mixed. The first stock solution contains the ammonium ferric citrate, the citric acid, and the oxalic acid, while the second contains the potassium ferricyanide.

The first stock solution is an unstable compound which is very sensitive to light. It must therefore be stored in a dark vessel and in a dark place. Under these conditions it will retain its properties for 7-10 days. The second solution is a quite stable compound and can be stored for a long time.

The ready light-sensitive compound, consisting of a mixture of the first and second stock solutions, retains its properties for a very short time (not more than a day or so); it is therefore recommended that it be prepared for a few plates before using.

Even 2-3 hours after mixing the compound begins to acquire a blue color. If such a compound is used for the preparation of

"phantom outlines," the latter will be produced with a considerable blue background. To prevent the solution from becoming blue or to remove the already beginning coloring, it is necessary to add a 1% solution of potassium permanganate to the finished compound or to the first stock solution in such an amount as to color the light-sensitive compound in a red-brown hue, which is retained for about 2-3 minutes. This amounts to approximately 10-12 ml of solution of potassium permanganate per 100 ml of ready light-sensitive compound.

The plates with the light-sensitive emulsion (particularly if it is already dried) must be thoroughly protected against daylight or against direct bright electric light. It is best to perform all operations, starting with the coating of the light-sensitive emulsion and ending with the washing of the finished copy, with a yellow-orange light. In extreme cases the operations can be performed with weak electric light.

In general the same technological process is used for the preparation of blue copies on paper, but since the base is not a gray metal, but a white paper, the image is sharper. Intensification is not desirable in this case, for treating paper with even a weak solution of acid deteriorates its quality, and this is particularly noticeable when compilation or publication originals of maps are prepared on this paper.

To obtain blue copies on paper it is therefore recommended that the process be carried out in 2 stages. The technological process consists of the following operations:

- (1) coating the light sensitive emulsion (only the first stock solution) and drying;

- (2) exposure;
- (3) treatment of the exposed copy with the second stock solution (development);
- (4) washing the copy with water (fixing). Drying the copy.

The coating of the light-sensitive emulsion is best performed with a cotton pad, abundantly soaked in the first stock solution. If this operation is performed accurately, it is easy to obtain uniform distribution of the emulsion on the paper. The drying can be either in a centrifuge or without it, and heating is not essential. Since the paper absorbs the emulsion well (something that does not occur when working with metal), the drying lasts several minutes.

The exposure is carried out in the same manner as working with metal. The difference lies in the fact that the light-sensitive emulsion does not contain potassium ferricyanide, and therefore no Turnbull's blue is precipitated, even though the iron is changed under the influence of light from trivalent to bivalent ($\text{Fe}^{+3} \pm h\nu \rightarrow \text{Fe}^{+2}$). The length of the exposure is chosen experimentally, best with the aid of a stepped exposure scale.

Treatment of the Exposed Copy with the Second Stock Solution.
The exposed copy is rubbed with a cotton pad, abundantly soaked with the second stock solution (potassium ferricyanide). This produces so to speak a development of the copy and a blue drawing appears. The process is very rapid, and the drawing is developed immediately after contact with the pad. The quality of the copy can be readily controlled visually, for the drawing resulting is quite bright.

Washing the Copy with Water. During the washing process,

- (2) exposure;
- (3) treatment of the exposed copy with the second stock solution (development);
- (4) washing the copy with water (fixing). Drying the copy.

The coating of the light-sensitive emulsion is best performed with a cotton pad, abundantly soaked in the first stock solution. If this operation is performed accurately, it is easy to obtain uniform distribution of the emulsion on the paper. The drying can be either in a centrifuge or without it, and heating is not essential. Since the paper absorbs the emulsion well (something that does not occur when working with metal), the drying lasts several minutes.

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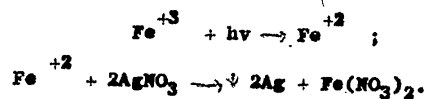
Washing the Copy with Water. During the washing process,

which fixes the image, all the salts are dissolved and carried away, with the exception of the insoluble precipitated salts which form the image. The result is therefore a blue drawing on a white surface of the paper.

The paper must be washed longer than metal plates, for the paper absorbs the light-sensitive emulsion to a considerable depth. To remove the emulsion, the washing should last not less than 20-25 minutes. It is best carried out in a tray with running water. The well-washed copy is dried and it is immediately ready for work.

21. Preparation of Argentotype Brown Copies

The preparation of brown prints -- the so-called argentotype copies -- is of great importance for the compilation and planning of maps. For example, argentotype brown copies can serve as compilation originals for single-scale maps, atlases with overlays, and publication originals for special maps in atlases, made up on a single printing base. This is why the demands imposed on argentotype copies are high, mostly requiring that the quality of the drawing be as close as possible to the reproduced original. Argentotype brown copies, the same as blue ones, are prepared on the basis of certain ferric oxide compounds which turn into ferrous oxides under the influence of light. Here, however, one employs the ability of the ferric oxide salts to reduce silver nitrate to metal in an aqueous medium. This process can be represented as follows:



It can be seen from the above reaction that the metallic silver is precipitated and forms an image of dark brown color.

This is why these prints are called "brown prints." The more metallic silver precipitates in the formation of the image, the darker its color, and vice versa.

This method was not widely used up to recently owing to many shortcomings.

The principal shortcoming of argentotype copies is the appearance with time of a yellow background on the field of the paper that has no drawing on it, and the fading of the lines of the drawing. Experimental work performed at the NRECh (Ye. N. Spiridonova and M. G. Finger) have established the causes of these shortcomings and possibilities for their elimination.

The appearance of the background is explained by the fact that it is impossible to eliminate from the paper completely the silver nitrate, which when exposed to light decomposes in time, and liberates metallic silver. To eliminate this shortcoming it is necessary to reduce the absorbing ability of the paper so that the solutions react and dry on its surface only during the processing. The means employed up to recently for this purpose did not give favorable results. The absorbing ability of the paper was reduced by treating it with a solution of gelatine or by introducing gelatine directly into the light-sensitive emulsion. The use of gelatine reduces the absorbing ability of the paper, but the sulfur, frequently contained in the gelatine can react with the silver ions and with the iron ions to form silver sulfide (Ag_2S) and iron sulfide (FeS), which color the paper and form a fog. Gelatine is therefore not suitable for the reduction of the absorbing ability of paper.

Of the other materials experimentally tried, the best results

were obtained with starch. If the paper is treated with a starch solution, the background does not become colored. Additional treatment of the paper with potassium alum reduces even more the absorbing ability of the paper and improves the quality of the argentotype copies.

The preparation of the argentotype copies consists of the following operations:

- (1) sizing the paper so as to reduce its absorbing ability;
- (2) coating the light-sensitive emulsion on the paper and drying it;
- (3) exposure;
- (4) development of the copy;
- (5) fixing;
- (6) washing the copy and drying.

Sizing the Paper. The paper is sized with a 3% solution of starch. The starch solution is coated on the paper with a cotton pad and is uniformly distributed over it. The paper is then dried, after which a cotton pad soaked in a 3% solution of potassium alum is used to treat the paper, which is then dried again. The starch solution is relatively easy to coat on the paper and to spread uniformly over its surface. Lightly penetrating into the thickness of the paper, it produces simultaneously on its surface a thin hydrophilic film. The starch solution does not change the color of the paper. The methods of coating the paper with the starch solution remain the same as the others used for coating solutions with the aid of a pad. The light-sensitive emulsion is coated on the paper that has been treated in this manner and dried.

Coating the Light-Sensitive Emulsion. The light-sensitive

compound used in this method is a mixture of solutions of ammonium ferric citrate and silver nitrate, which are prepared separately and mixed before using. When preparing the solution it must be borne in mind that the oxide ammonium ferric citrate must be completely free of even the slightest traces of ferrous oxide, for the latter is capable of reducing the silver nitrate to metal, which may result in the production of fog. As a precautionary measure it is possible to add to the light-sensitive solution potassium permanganate in an amount of one ml of 2% solution of KMnO_4 for each 100 ml of ready light-sensitive compound.

The ammonium ferric citrate can be either brown or green. The green one increases the light sensitivity of the emulsion by approximately 2-2.5 times compared with the brown one. The sensitivity is substantially affected by the organic acid contained in the composition of the layer. The oxalic acid, for example, results in solutions that are more sensitive than acetic acids. The light-sensitive solution must be prepared with distilled water, for the chloride salts contained in tap water may combine with the silver nitrate to form silver chloride (AgCl), which may produce fog if insufficiently fixed, by being reduced to metal in light.

The prepared compound is sensitive to light and must therefore be stored in a dark place and in a vessel made of dark glass.

The light-sensitive emulsion is coated on the surface of the paper with a cotton pad without pressure so that it stays on the surface without penetrating deep into the paper. The coating should be done in an even and thin layer in a nonactinic illumination (orange-yellow) and as fast as possible. Sixty to seventy ml of light-sensitive solution are enough for one m^2 of paper.

The paper coated with the light-sensitive emulsion must also be dried rapidly, to prevent the light-sensitive solution from penetrating deeply into the paper. It is therefore best to dry the paper in a cabinet or some other device provided with heating and ventilation. After drying and seasoning the paper can be exposed.

Exposure. The exposure is performed in the same manner as used for production of blueprints. The duration of the exposure is determined in the usual manner. The exposure used at the MRKCh fluctuates under various conditions between 15 and 25 minutes.

During the exposure time the ferric oxide salt is transformed under the influence of light into ferrous oxide, and reacting with the silver nitrate in the emulsion, it causes the separation of metallic silver and its precipitation as a precipitate that is insoluble in water, forming the image. In addition to metallic silver, the emulsion contains other substances after exposure, and these must be removed from the surface of the paper. The principal ones are the iron and silver salts that did not participate in the reaction, and which are removed by washing and fixing the copy in water.

The washing should eliminate all the compounds soluble in water, so that they do not spoil the copy subsequently. It is therefore necessary to wash in running water not less than 10-15 minutes. The copy is immediately fixed after washing.

Fixing. Fixing is in a solution of hypo and sodium sulfite. After fixing, which lasts for 3-5 minutes, the copy must again be thoroughly washed, to remove the fixation products and the remnants of the fixing solution. The washing in running water should not be less than 10-15 minutes. After washing, the copy is dried and it is ready for use.

Experimental work performed at the NRKCh has shown that argentotype copies, obtained by the above method, yield a sharp dark-brown drawing and a white non-yellowing background.

PART II

PRINTING FORM PROCESSES

CHAPTER 8

FUNDAMENTALS OF PLANOGRAPHIC PRINTING

The production of the printing form reduces to the formation of printing and blank elements on the material of the form. In flat printing this usually represents a complicated process.

In the form used in relief printing, the printing elements project over the blank spaces, and therefore an inked roller rolling over the form, touches only the printing elements, without touching the blank elements, and the imprint shows the printing elements covered with the dye (Figure 52).

A form for intaglio printing, to the contrary, has the printing elements in depressions. The entire form is coated with the ink, and after it is removed the ink remains only in the depressions, i.e., on the printing elements. Consequently, the imprint can produce only the printing elements that are covered with ink (remaining in the depressions) (Figure 53).

An imprint made with a planographic form should also reproduce the printing elements only. But since both the printing and the blank elements of this form are in the same plane, it is impossible to employ the relief or intaglio printing principles.

This is why the printing and blank elements of planographic form should have different properties, making it possible for the former to accept the ink, and for the second to resist it. These properties of the printing and blank elements are expressed in their abilities to become selectively wetted: the printing elements are wetted by the greasy printing ink, and the blank ones by water. The form should be sufficiently stable and irreversible during the printing run. The printing elements are called hydrophobic (sometimes oleophilic), and the blanks are called hydrophilic.

The process of producing printing and blank elements on the planographic printing form is still insufficiently studied, and there is no complete theory yet to answer all the questions. Investigations carried out in this field by our scientific research institutions and by individual scientists, however, explain the general laws of the process.

22. Physical-Chemical Features of Surface Films. Free Surface Energy. Adsorption. Selective Wetting.

Surface layers of bodies existing in nature have specific features and properties. These properties are determined by the presence on the surface layers of the so-called free surface energy, which is a result of the unique distribution of matter.

The presence of surface energy is explained by the fact that the molecules of the substance, located on the surface of the body, are not in equilibrium, since they experience unequal attraction on the part of the molecules located on both sides of the separation boundary. Let us examine this by using the following example.

Figure 54 shows 2 molecules of a liquid, located at different distances from its surface. As can be seen, molecule 1 is attracted by the neighboring molecules on all sides equally, while molecule 2 is attracted only on one-half, since its second half is the boundary of the body. Consequently, in this molecule the electrostatic forces are not fully balanced by attraction from other molecules, and it has a reserve of excess free energy. This excess free energy of the molecules of the surface layer is called the surface energy. It is seen from the above example that the resultant force on molecule 1, which experiences equal attraction on all sides from the neighboring molecules, is zero, while that on molecule 2, which is not fully balanced by attraction from neighboring molecules, the resultant is not zero and is directed inside the body. This is why surface molecules of liquid are sometimes under the influence of a force that tends to pull them inward, and this explains the tendency of the liquid to have a minimum surface for a given volume, as seen particularly in the spherical form of drops.

The surface energy can be characterized by surface tension. The value of the surface tension differs with the substance. In the case of water, for example, at a temperature of 20°C , the surface tension is 72.75 erg/cm^2 , that of benzine is 29.0, of acetic acid is 28.0, and of ethyl alcohol is 22.0, etc.

Increasing the temperature weakens the intermolecular attraction forces. The value of the surface tension naturally also diminishes with increasing temperature. Thus, for example, the surface tension of water is 75.64 at 0°C , 72.75 at 20°C , 66.8 at 60°C , and 62.61 erg/cm^2 at 80°C .

When various substances become dissolved in a liquid, the surface tension of the liquid changes. If organic compounds (alcohols, organic acids, etc) are dissolved in the liquid, the surface tension decreases. If inorganic salts are dissolved, the surface tension increases. The concentration of the dissolved substance in the surface layer and inside the liquid is not the same. It may be greater or smaller on the surface layer than inside. This property, namely the change in the concentration of the substance in the surface layer compared with the concentration inside the phase, is called adsorption.

If the concentration of the substance in the surface layer is greater than inside the phase, the adsorption is called positive, but if the concentration is less at the surface than inside, it is called negative. Substances that are adsorbed from the liquid positively and thus reduce the surface tension are called surface active. Such substances include alcohols, fatty acids, and other compounds, the adsorption of which reduces the surface tension on the surface of any body.

Everything said above concerning the free surface energy applies not only to liquid, but also to solids, the surface molecules of which (atoms or ions) have an unbalanced portion of the force field, i.e, have a free surface energy. A solid tends to reduce its free surface energy by adsorbing on its surface substances having particles with a lower force field. Adsorption plays a very important role in all printing processes. Naturally, the greater the free surface energy, the more active the adsorption.

In the case of solid bodies, the adsorption of molecules on the surface, reducing the free surface energy, occurs when the solid

interacts with the solutions (or gases) with which it is treated. Thus, the adsorption can be considered as the ability of the surface of solid bodies to adsorb and to soak in substance from the surrounding medium (liquid or gas) into the surface layer, and consequently, to change the molecular nature of the adsorbing body.

The surface layer with free surface energy is small. Its thickness equals the diameter of the molecule, i.e., it is a monomolecular layer.

A body on whose surface a substance is adsorbed is called an adsorbent, and the substance which is adsorbed on the surface of the adsorbent is called the adsorbative.

Adsorption of some substance on surface of others causes the surface layers of the latter to acquire properties that are new for the given body. Of particular interest in map publishing is the adsorption of surface-active substances on the surface of a solid body.

Surface-active substances differ in that they have a so-called asymmetrical molecule structure. The asymmetry in the structure of the molecules lies in the fact that each molecule has a polar and a non-polar part. The polarity or non-polarity of bodies depends on the structure of the molecules and on the type of the bonds between them. In a molecule that is electrically-neutral (on the whole) the charges may be uniformly distributed, and in which case the molecule is non-polar. If positive charges predominate in one part and negative ones predominate in the other, the molecule is called polar. Polar compounds include, for example, water, and non-polar ones include hydrocarbons. The extent to which a solid surface becomes wetted by some liquid depends on the similarity

in the physical-chemical properties of the surface layers of the interacting substances. The closer the polarity of the bodies, the greater the wetting, and to the contrary, the farther apart their polarity, the less wetting occurs. If the bodies are anti-polar, wetting is impossible. Thus, the smaller the difference between the polarities of the surfaces of the bodies that are being wetted and the liquid that wets it, the better the wetting.

In the case of adsorption of surface-active substances, the molecules of which are asymmetrically constructed, the latter are rotated with their polar part towards the polar medium and with their non-polar part to the non-polar medium. Polar compounds that are close in their physical and chemical properties to water are called hydrophilic, while non-polar compounds that have opposing properties are called hydrophobic.

The printed form results from the ability of a substance to orient itself in a definite manner on the surface of the solid body, making it possible to produce on the form of material both hydrophobic and hydrophilic surfaces. If one forms on the hydrophilic surface an adsorption film of a surface-active substance, the molecules of which have an asymmetrical structure (for example, fatty acids $C_{17}H_{23}COOH$, where $COOH$ is the polar group, and $C_{17}H_{23}$ is the non-polar hydrocarbon chain), it can be converted into a hydrophobic surface (Figure 55). To the contrary, a hydrophobic surface can be converted in the same manner into a hydrophilic surface (Figure 56). Thus, by choosing the proper substances for the treatment of the form material, it is possible to obtain a hydrophobic surface (printing elements) and a hydrophilic surface (blank elements) and consequently impart to the printing form the property of selective wetting.

Priority in the development of the theoretical foundations of selective wetting on planographic printing forms belongs to Soviet scientists. Of great importance are the workby academician P. A. Rebinder, who not only worked out the scientific theory, but developed a method for quantitatively measuring the wettability under selective conditions.

A drop of water placed on a hydrophilic surface flows readily and freely over it (Figure 57a). If a line is drawn tangent to the surface of the water on the boundary (separation) with air, it forms a sharp angle with the surface (Figure 57b). If the surface is less hydrophilic, a water drop will not flow freely on the surface, and the tangent to the surface does not make so sharp an angle (Figure 58). On a hydrophobic surface the drop will not spread at all, and the tangent makes an obtuse angle with the surface (Figure 59). This angle is called the boundary wetting angle and is denoted by the letter θ .

Thus, the angle θ characterizes the degree of wettability of a solid surface by some liquid, and consequently the hydrophilic or hydrophobic nature of the surface. It is seen from the above drawings that maximum hydrophilism is attained when θ is nearly equal to zero and diminishes with increasing value of θ , which theoretically (for a completely hydrophobic surface) may become 180° .

By way of a direct measure of the wettability, P. A. Rebinder suggested the use of not the angle θ itself, but the quantity $B = \cos \theta$, which varies from 1 (at $\theta = 0^\circ$) to -1 (at $\theta = 180^\circ$).

23. Formation of Printing Elements

In planographic printing the printing elements are formed

in 2 manners: in one case -- directly on the surface of the metal from which the form is made (most frequently aluminum), and in the other -- not on the surface of the metal itself, but on a thin film of hardened colloid placed on the metal. In both cases the process of the formation of the printing elements is controlled by different laws.

Formation of printing elements directly on the material of the form aluminum and zinc (more accurately, a thin film of the oxides of these metals, formed on their surface by exposure to air), used for the preparation of printing forms, have the property that they can be separately wetted by fatty acid and water. To obtain a stable printed form it is necessary that the printing elements not only be well wetted by the substances containing free fatty acids (drying oil, offset or transfer ink, etc), but to become wetted by them in the presence of water and at the same time not become wetted by the water. To accomplish this purpose, it is necessary to coat the surface of the future printing form of the drawing with such a substance, that would become well adsorbed on the surface of the metal, and being surface active, would make it possible to produce a layer of specially oriented molecules, which are adsorbed in their polar part on the material of the form (aluminum or zinc), leaving the nonpolar part free. This nonpolar surface will then so to speak repel the water (which is polar) but will take substances (such as greasy ink) which have similar polar properties.

Oleic acid, which is used to produce printing elements on the forms, has such properties. What is usually employed for the purpose is not oleic acid in its pure form, but materials which contain it (free fatty acids) in considerable quantities. Such materials are transfer, offset, and lithographic pigments, lithographic ink, and many others.

Formation of Printing Elements on a Thin Film of Hardened Colloid. Colloids are a group of substances having specific properties. (For more details on colloids see Section 26).

Colloids in themselves have little light sensitivity and hardly change their properties under the influence of light. But under certain conditions in the presence of certain substances they change their properties completely under the influence of light, and this is used for the preparation of printing forms.

A hardened film of chromated colloid (for explanation of hardening [tanning] process see Sections 26 and 28) is capable of adhering strongly to the material of the form, and acquires clearly pronounced hydrophobic properties, and as shown by the investigations by V. S. Lapatukhin [9], permits easy diffusion of fatty acids, thereby leading to the creation of printing elements.

24. Formation of Blank Elements

Once the printing elements are formed on the metal, it acquires in those places the property of selective wetting by fatty acids. For the printing process to run normally, the blank spaces must acquire the property of selective wetting by water. This is accomplished by producing on a thin film of hydrophilic colloid, which covers the surface of the metal in the blank spaces, swells up when moistened, and retains the moisture in it.

All the known manufacturing recipes for compounds used in the hydrophilization of the blank spaces of the printed form contain solutions of hydrophilic colloid (dextrin, starch, gum-arabic, etc) and electrolytes (phosphoric acid, its salts, etc).

Investigations have shown that the moisture carrier, that prevents the adhesion of the fatty printed ink on the blank spaces, is a thin film of colloid, which is strongly attached to the material of the printed form.

Up to recently almost all investigators assumed that the function of the electrolyte is to destroy the film of the metal oxide, which forms on the surface of metal that comes in contact with air (for example Al_2O_3), and to facilitate the fixing of the colloid film contained in the hydrophilic substance on the surface of the pure metal. In recent times some new ideas have been expressed concerning the role of electrolytes of the hydrophilizing solutions. The investigations by V. S. Lapatukhin [10] lead to the conclusion that the electrolytes, by interacting with the material of the form, produce on its surface phosphates of metal that are insoluble in water, and which first adsorb well the colloid of the hydrophilizing substance, and second produce a large expansion in the surface (up to 300%), thus increasing this adsorption.

Figure 60 shows a magnified cross-section through the printing form, prepared by negative copying. The form produced by positive copying (Figure 61) shows in general the same picture, with the only difference that the printing elements are depressed (by 12-15 microns) and the layer of the printing ink lies on a layer of lacquer [10].

CHAPTER 9

PREPARATION OF PRINTING FORMS BY NEGATIVE COPYING

The process of preparing the printed form by negative copying consists of the following successively-performed operations:

- (a) Preparation of the metallic plate (selection and inspection

of the plate and determination of the suitability, removal of the old drawing, graining the plate, washing, and drying).

(b) Coating the plate with a light-sensitive solution and its drying -- sensitization of the plate.

(c) Copying from the negative onto the sensitized plate.

(d) Development of the copy.

(e) Final processing of the resultant printed form and check of its quality.

Let us consider each operation individually as applied to the conditions prevailing in the preparation of printed forms for publication of maps.

25. Preparation of Metallic Plate

The material for the preparation of the printed form in map publishing is principally aluminum, and in very rare cases zinc. This is why procedures for aluminum plates will be considered below, but the formulas for some compounds will in certain cases be given also for zinc plates.

The grades of commercially available aluminum suitable for the purpose are: grade A-1 (contains 99.5% aluminum), A-2 (contains 99% aluminum), and A-3 (contains 98% of aluminum). Rolled aluminum is produced and delivered to the cartographic factories in sheets measuring 120 x 300 or 150 x 300 cm, 0.7-0.8 mm thick.

The extraneous impurities [admixtures], which in aluminum sheets amount to from 0.4 to 2%, are iron, silicon, manganese, and others. Compared with zinc, aluminum has a relatively higher tensile strength and in particular higher resistance to elongation. It is therefore employed widely for forms used in map publishing. The

strength of pure electrolytic aluminum is considerably lower than that of aluminum with admixtures of iron, silicon, or manganese. However, a large amount of admixtures (above 1-2%) affects adversely its operating properties and frequently causes corrosion and other faults that spoil the printed form.

When exposed to air, aluminum rapidly oxidizes and its surface becomes covered with an oxide film, consisting of aluminum oxide (Al_2O_3). The oxidation is faster in moist air and the aluminum oxide is transformed into the hydrate of the oxide. The oxide film is very hard and exerts a protective action. Forming rapidly and covering the surface with a very thin film, it prevents further oxidation. The oxide and other films, forming on the surface of the aluminum plates during their multiple treatment, play an important role in the process of preparation of printing forms.

Before the aluminum plate is used in production, it must be inspected, to see to it that it has no deep scratches and other surface disorders, which disturb the formation of printing and blank elements or which make the process difficult. In addition, the plates should be of a definite shape and of standard thickness, and this is of particular importance in the selection of plates for the preparation of machine printing forms. The edges of the plates must be even.

If a previously-used plate is to be reused, the old drawing must be removed from it. The protective layer of collodion is removed with water or with a brush (or a pad [swab] of coarse cloth). After removing the protective layer, the dye of the old drawing is washed off it can be removed with a pad moistened in kerosene or turpentine. Instructions on the graining of plates, in force in

cartographic factories of the GUGK, call for the dye to be removed with a solvent of the following composition:

Kerosene	500 ml
Turpentine	500 ml

and to perform this operation by brushing the plate.

After removing the old drawing, it is necessary to remove the oleophilic (hydrophobic) layer that is adsorbed on the surface of the plate, and which serves as the base for the printing elements. It can be removed also during the graining process, but this is not advisable, for first this increases the graining time, and second it is difficult to establish accurately whether the old drawing is fully removed. It is therefore more advisable to remove the old drawing prior to graining and outside the graining machine.

It was assumed up to recently that the best way to remove the old drawing, as well as to degrease and clean the aluminum plates, is in a 25-30% solution of nitric acid (HNO_3). Better results are obtained, however, by removing the old drawing from used plates by treating them with alkali, a practice that has been adopted in recent years by many enterprises. The alkali, which saponifies the fats that form the image, makes the latter easy to remove from the plate. Strong alkalis, in addition, react vigorously with aluminum and with its salts and by virtue of this clean the surface reliably. If this operation is performed by brushing the surface and adding a small quantity of fine abrasive, the old drawing can be fully removed. The instruction recommends for this purpose a solution having the following composition:

Caustic potassium or sodium (KOH or NaOH)	50 g
Water	1,000 ml

The gases liberated when aluminum is treated with alkali are harmful to the health of the workers, and this is why any device for the removal of the old drawing should be provided with ventilation.

After removing the old drawing the plate should be thoroughly washed until all traces of alkali are removed.

New plates, never used before, must also be treated with alkali to remove from their surface the various contaminants, including fatty ones.

An aluminum plate prepared in this manner can then be grained. The graining is a very important stage in the entire technological process of the preparation of the printing forms for map publication. The quality and stability of the printing and particularly of the blank elements depend considerably on the quality of the graining, and the dimensions and the character of the grains obtained as a result of graining are of decisive significance. The magnitude of the grain and its character depends on many factors, the principal of which are as follows: (a) dimensions and hardness of marbles and particles of the abrasive material, (b) duration and conditions of graining, (c) ~~dimensions and~~

(a) Dimensions and Hardness of the Marbles and Particles of Abrasive Material. The grain on the surface of the plate is produced by marbles (mostly porcelain) rolling over the surface and pressing against the particles of the fine abrasive, forcing them into the metal, and forming in the latter minute recessions in the form of pinpricks. To obtain fine grain it is necessary that the dimensions of the abrasive particles also be sufficiently small. But with a fine abrasive one can use only marbles of small diameter, since

larger marbles will not press the particles of fine abrasive into the metal and will not produce the required grain. To the contrary, they will polish the plate. In addition, the hardness of the abrasive must be somewhat higher than the hardness of the porcelain marbles, for otherwise the abrasive will become readily pulverized and will not be able to form the grain.

The hardness of the porcelain, on the Moos scale, fluctuates between 6 and 6.5, and consequently the abrasive must have a higher hardness. The most widely used abrasive for graining aluminum plates, are the following.

Carborundum -- Silicon Carbide. Its hardness on the same Moos scale is 9.5. Carborundum, or silicon carbide, is produced by melting coke and sand in electric furnaces at a temperature of 2,000°. When crushed, it forms small rhombic grains with sharp edges. A valuable property of carborundum is that when it becomes ground down during the graining process it retains the sharp edges longer than other abrasives.

Corundum. This is a natural mineral. Its hardness is approximately 8. It consists mostly (90%) of aluminum oxide.

Electrocorundum. Aluminum oxide (from 87 to 97%) obtained artificially in special furnaces. Its hardness is somewhat higher than that of natural corundum.

Emery. It is a natural mineral. It contains 40-50% aluminum oxide and a considerable amount of iron oxide. Its hardness is somewhat less than that of corundum. Finely pulverized emery forms particles with uneven fractures and with sharp edges. It may produce a sharp and fine grain during graining, but is strongly pressed into the metal.

Quartz Sand. A natural mineral. Hardness 7. When crushed it forms particles of irregular form with sharp edges.

Quartz Dust (Marshallite). Finely crushed quartz sand, which passes readily through a sieve with 100 holes/cm.

Natural Pumice. A natural mineral. Hardness approximately 6. Readily pulverized into a fine powder.

Up to recently the abrasive used was almost exclusively pumice powder. The information given above is evidence that the use of pumice as an abrasive for the graining is not justified technically, for it is softer than the porcelain marbles, and cannot therefore produce the required grain on the plate for the printing form.

In recent times electrocorundum, corundum, and quartz sand are used most frequently. The instruction on plate graining recommends that the abrasive used be Marshallite.

Marshallite, which is thinly crushed quartz sand, consists principally of silica (98%). It contains small amounts of the following admixtures: calcium oxide (CaO), magnesium oxide (MgO), and iron oxide (Fe_2O_3). Sometimes it contains also admixtures of active alkalis, which may exert a harmful effect on the surface of the grained plate. The dimensions of the abrasive particles are characterized by the following indices: residue in a No 100 sieve -- not more than 2%, 140 -- not more than 5%, 200 -- not more than 10%, and 270 -- not more than 70%. As can be seen, the particle dimensions are very small, and this ensures the production of a fine grain, suitable for the preparation of printing forms for maps with very fine open linework. The most suitable diameter of the porcelain marbles for graining machines operating at 150-200 rpm is 10-12 mm.

If steel marbles are used for the graining, the diameter may be 8-10 mm. The shape of the marbles plays a serious role in the graining process. In order to obtain uniform and identical grain over the entire surface of the plate, the marbles should have a correct shape. Of great importance is also the uniformity of the composition of the marbles. If the composition is not uniform, different parts wear unevenly and the marbles lose rapidly their spherical form. The marbles must be sorted from time to time, discarding those that are too worn (having a diameter less than 7-8 mm) and those who lose their spherical form.

(b) Duration and Conditions of the Graining Process. If the graining process is examined from time to time, it can be seen that after 15-20 minutes after the start of the graining the plate has a uniform grain with depressions that are close in size to the particles of the abrasive and that the edges of the grain are somewhat smoothed. As the graining continues the depressions first formed become smooth, but smaller depressions appear in ever increasing numbers, and are formed by the smallest particles of the abrasive that breaks up during the graining process.

During the graining process, the abrasive material is easily broken up into particles which are no longer in position to give the required depressions on the grained surface. Thus, 15-20 minutes of grinding and wearing causes not only pumice, but also marshallite and electrocorundum to turn into very fine powder. Since the graining process takes place in a moist state, the powder forms a sufficiently fine paste, capable of only polishing the surface of the plate, and does not produce the required grain.

At the same time the smoothing that is produced during the graining process, following the first production of the grain, is exceedingly useful for it ensures the equalization of the surface of the plate and the smoothing of small accidental scratches and of other faults. In order to obtain the required surface and the grain that is suitable for further work, the surface of the plate that has become smoothed during the first stage of the graining process must be grained again. This can be accomplished by adding fresh abrasive after 10-15 minutes until the graining is finished. The graining time depends on the character and dimensions of the required grain, on the abrasive, on the speed of operation of the graining machine, and on other factors, which are difficult to take into account. The graining time may fluctuate from 40 minutes to 1-1/2 hours and is established experimentally at the cartographic factories.

Graining is accompanied by a vigorous oxidation of the aluminum owing to the continuous exposure of the metal when the particles of the abrasive are pressed into it. The oxide films, which are continuously formed and which are continuously destroyed by the abrasive and by the balls, produce in an aqueous medium aluminum hydroxide, which remains in the depressions of the grain and which affect the functioning of the printing elements and particularly of the blank elements of the printing form. To prevent formation of a hydroxide precipitate in water it is necessary to introduce into it small amounts of organic acid (acetic, oxalic, citric). A 0.25% concentration of acid gives favorable results.

To obtain a fine and sharp grain on the plate it is necessary to observe the following conditions during the graining.

1. The abrasive must be chosen with a fine grain and its hardness must be somewhat higher than that of the porcelain marbles.
2. The marbles should have a diameter of 10-12 mm, have a correct spherical form, equal diameters, and uniform hardness.
3. The tub of the graining machine should move uniformly, and should be in horizontal position.
4. To produce a sharp and fine grain it is necessary to add fresh abrasive 10-15 minutes prior to completion of the graining. The instruction recommends that at 75% of the abrasive employed be used at the start of the graining, and 25% before completion.
5. The experimentally selected time and conditions of graining (amount of abrasive and of moisture, timing of addition of abrasive and moisture) must be strictly adhered to.
6. It is useful to add organic acid to the moisture (acetic or citric), with a concentration of 0.25%.
7. Particular care must be taken when charging the container with the plate with marbles and when removing the marbles from the grained plate. Careless loading or removal of the marbles may damage the surface of the aluminum plate by scratching or bending, or by producing other faults that affect adversely the quality of the printing form.

The grained plate must be thoroughly washed. During the graining process part of the abrasive material is ground down and is pulverized into very small dispersed particles, and the marbles themselves become worn. In addition, both the marbles and the abrasive material grind the particles of the metal and of the oxide films that cover it. All this forms a finely dispersed mixture when moistened, filling the depressions of the grained surface and sticking

there. If this ground substance (slime) is not removed in time, it may affect adversely the quality of the finished printing form. The purpose of washing after graining is therefore the removal of the slime from the surface of the grained plate. The washing is best performed in 2 steps: first with a strong stream of water so as to wash out as much slime as possible from the grained surface and to wash the reverse side, and then a second washing of the grained surface with a stream of water, with simultaneously thorough brushing.

The washed plate must be dried rapidly. Rapid drying causes the aluminum plate to oxidize immediately upon contact with the air, and to be covered with a uniform thin film of oxide (Al_2O_3). This film protects the metal against further oxidation. If the drying is slow and uneven, the oxidation is uneven, and the presence of the water on the surface of the plate leads to corrosion. This process is slowed down in the absence of water and ceases completely if all the water is removed.

26. Colloids. Light-Sensitive Solutions

The light-sensitive emulsions used for the preparation of printing forms by the negative and positive copying methods are solutions of chromated colloids, i.e., solutions, the components of which are colloids and bichromate salts of ammonium (NH_4) or potassium (K). The most useable natural colloids are albumin (for negative copying), gum-arabic, resin from Siberian larch, dextrin, gelatine, and their various mixtures (for positive copying). The most extensive experiments with synthetic colloids were made with polyvinyl alcohol.

Before we consider the modern views on the physical-chemical nature of the processes of formation of the image in negative copying, let us become acquainted briefly with certain scientific data on colloids.

If any substance is broken into particles of a given size (disperse phase), which are distributed in some medium (dispersion medium), the result is the formation of a dispersed system. Dispersed systems can differ in the size of the particles, which is customarily called the degree of dispersion of the substance. Depending on the degree of dispersion, systems can be coarsely-dispersed, colloid-dispersed or molecular-dispersed (solutions). Among the coarsely-dispersed systems are suspensions, i.e., systems in which the particle dimensions exceed one micron. The particles of a suspension do not remain suspended indefinitely but settle under the influence of gravity. Therefore suspensions are kinetically unstable systems. Suspensions are not capable of diffusion. In colloidal systems the particle sizes range from 0.001 to 0.1 microns. Colloidal systems are kinetically stable. They are capable of diffusion. A system in which the individual molecules of the substance are distributed between the molecules of the medium are called solutions.

Without discussing coarsely-dispersed systems and solutions, let us dwell on colloidal systems.

A colloidal system is a heterogeneous system, i.e., such in which the individual particles differ in composition and are separated from each other by a separation boundary (particles of the dispersed phase and of the dispersion medium). The presence of a separation boundary indicates the presence of free surface energy, which increases with the total area of the phase-separation surface.

As in any other system, the substance tends to reduce the free surface energy either by adsorbing on the surface of the colloidal particles substances that reduce the size of the surface tension, or by enlarging the dispersed particles themselves, i.e., by decreasing the degree of dispersion. This is why colloidal systems are aggregate-unstable systems.

The structure of colloidal particles, according to modern use, can be represented in the following form. The colloidal particle is an aggregate of a large number of molecules or atoms of a given substance, which form the nucleus of the particle, surrounded by a double layer of ions, consisting of an adsorption and diffuse portions. The nucleus together with the double electrical layer is indeed the colloidal particle, called a micelle.

If a liquid dispersion medium contains distributed particles of a solid dispersion phase, such a system, unlike solutions is called a sol.

Particles of the dispersed phase most frequently tend to reduce the reserve of the free surface energy by increasing the particle size, i.e., by joining and merging minute particles into larger ones. Under certain conditions, the particles increase and join and thereby lose their ability to move forward, and the liquid contained between them loses its mobility, and the system changes from a sol into a jelly, which is called a gel.

In liquid colloid systems, the particles of the dispersed phase may increase to such large dimensions that they cannot remain suspended and become precipitated. The process of increase of the colloidal particles, i.e., the reduction of the degree of the dispersion of the system, is called the coagulation process.

Of particular interest in map publishing are certain high-molecular compounds, which have specific properties, which in many cases differ sharply from the remaining colloids. High-molecular compounds or high polymers include albumins, cellulose and its derivatives, starch, and other compounds. Solutions of high polymers have many properties of typical colloidal systems, (for example, low diffusion speed) and at the same time have certain properties of true solutions, i.e., of a molecular dispersed system (for example, reversibility).

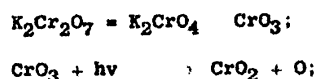
At the present time there is a tendency to consider high polymers as halogenic systems, i.e., systems in which there is no separation surface between particles -- true solutions. Apparently, colloidal solutions of high-molecular compounds occupy an intermediate place between the colloid-disperse and molecular-dispersed systems.

The most widely used in map publishing are albumin colloid compounds (albumin, gelatine, etc). These compounds become hardened under certain conditions, and this manifests itself in a loss of the solubility and to a considerable extent in swelling.

This process can be explained by the fact that the number of bonds between molecule (the so-called transverse bridges -- "bridge bond") increases under the influence of light, and the reinforcement of the intermolecular bonds leads to their joining (adhering) into larger aggregates all the way up to complete coagulation.

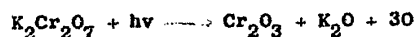
In map publishing processes, the hardening substances used are ammonium or potassium bichromate. According to the latest views, the bichromate is added to the light-sensitive solution to act

as an optical sensitizer which imparts the light energy to the colloid molecules. A widely held view is that the action of light removes oxygen from the bichromate, and it is the oxygen that acts as the hardener. If potassium bichromate is used, this is represented by the following equation [16]:



gelatine + O $\rightarrow$ insoluble gelatine.

Many believe, however, that the colloid coagulates as the result of the reduction of the hexavalent chromium into a trivalent one, and that the hardener is not the oxygen alone, but also the Cr_2O_3 which is formed at the same time. In this case the reaction can be represented by the following scheme



It is quite probable that the oxygen, which binds together the free bonds of the molecules, acts as a "bridge" in the bridge bonds between the molecules, causing coagulation of the colloid.

The physical-chemical nature of the hardening process of non-albuminous substances, widely used in the preparation of printing forms, particularly in positive copying (gum-arabic, resin of Siberian larch, and other resins or tars) consists apparently also of the formation of bridge bonds between molecules, and at the same time the hardener or the oxygen liberated by the bichromate acts as the bonding element.

Dry coagulated colloid, as any other coagulated substance, changes its property towards hydrophobia. This is why it acquires upon hardening the property of becoming well wetted and capable of

retaining in its surface fatty acids or substances containing them in considerable quantities.

The colloid most frequently used for negative copying is albumin (from eggs or from blood), and the hardeners are chromate salts of ammonium (NH_4) or potassium (K), principally bichromates ($\text{K}_2\text{Cr}_2\text{O}_7$) and $((\text{NH}_4)_2\text{Cr}_2\text{O}_7)$, with the latter imparting to the copying emulsion a somewhat greater light sensitivity.

There are many formulas for chromated albumin, which give quite satisfactory results. By way of example, we list some of them (Table 15).

TABLE 15

Components	Unit of measurement	Formula 1	Formula 2	Formula 3	Formula 4
Egg albumin,					
dry	gram	45	40	35	35
Ammonium bi-					
chromate	gram	14	16	20	16
25% ammonia	ml	6	6	2-3	2.5
Water	ml	1,000	to 1,000	1,000	1,000

The instruction in force at the GUGK enterprises specifies Formula No 2.

The rôle of the albumin and of the ammonium bichromate can be understood from what has been said above. In this case the amount of bichromate salts exerts a certain influence on the light-sensitivity of the solution. It is customarily assumed that increasing the bichromate content in the copying solution increases the sensitivity of the solution; this is experimentally confirmed in many cases. Judging

from the preponderant majority of recipes, the content of ammonium bichromate in a solution should not be less than 1.5%. Increasing the bichromate content to 2.5-3%, increases somewhat the light-sensitivity of the solution. Increasing the bichromate content in a solution of chromated albumin above 4-5% no longer exerts a noticeable influence on the light sensitivity of the solution, and if the contents are increased above 5%, it crystallizes out of the copying solution.

The ammonia in the light-sensitive copying emulsion serves to reduce the effect of the spontaneous (dark) hardening, which takes place to a lesser or greater extent in the dried film of chromated albumin even in darkness. The useful role of ammonia manifests itself in the fact that the ~~orange~~ color of the emulsion becomes bright yellow in its presence, making it possible to reduce the exposure required during copying.

27. Coating the Copying Solution on the Plate

The coating of the chromated albumin onto the plate is a vital process. To reproduce fine line work of the cartographic image the copying emulsion should be coated on the plate with particular care.

No matter how carefully the grained plates are stored, their surface is always soiled by something. To remove the traces of dirt, the plate must be washed and brushed in a 0.5-1.0% solution of sulfuric acid. To remove dirt, 3-5 minutes washing is enough. Brushing the plate removes the dirt and the remnants of the slime not only from the surface, but also from the depressions in the grain. Treatment with the acid damages somewhat the old oxide film. Cleaning the surface of the aluminum plate contributes

to a more uniform coating of the copying layer and to stronger adhesion of the latter, and this is of great significance in the formation of stable printing elements.

After the plate is treated with acid and washed sufficiently (until all traces of acid are fully removed from the surface), it is advisable to treat it in a 5-6% solution of starch, which is necessary to produce stable blank elements.

A gauze pad [swab] is used to cover the plate with a thin layer of starch, which is then dried. Before coating the copying emulsion, the starch is washed off the plate, also with a gauze pad.

In addition to producing a hydrophilizing effect on the aluminum plate, the starch remains in part on the plate when the latter is washed prior to coating the light-sensitive emulsion, and keeps a water film on the surface of the moistened plate. The starch also helps remove the unhardened chromated albumin from the form. After the plate has been treated with starch, there is less diffusion of fatty acids, through the unhardened layer of the chromated albumin when it is covered by the copying ink.

The light-sensitive solution should be coated on the plate in a uniform layer that is as thin as possible. It is best to coat it in a centrifuge [whirler]. The plate should be located in the centrifuge symmetrically on a crosspiece (or grid), otherwise the solution will not be distributed uniformly on the plate.

To permit the copying solution to flow uniformly over the plate, it is first moistened. For this purpose the plate which rotates in the centrifuge is liberally doused with a strong stream of water, which moistens the plates and washes off any accidental

dust and other dirt that may fall on the plate. After the excess water is removed from the plate (this can be determined visually from the fact that the surface of the plate becomes dull), the chromated albumin is poured on it, in previously-measured batches. The GUGK instructions specify the following amounts of solution, depending on the dimension of the plate:

For 50 x 60 cm plates	80 ml
For 65 x 85 cm plates	150 ml
For 120 x 140 cm plates	400 ml

The amount of albumin necessary to coat a plate measuring more than 65 x 85 and less than 120 x 140 cm can be determined from the fact that to obtain a high-grade printing form, the thickness of the layer should be a minimum.

The thickness of the dried layer of chromated albumin is of great importance in the formation of the image. If the layer is too thick, it is necessary to increase considerably the exposure so that it can be hardened fully; this is undesirable. If the layer is very thin, to the contrary, the hardening is too fast and the spontaneous (dark) hardening exerts a noticeable effect even in the case of an accidental exposure to amounts of actinic light that are normally too small for the given emulsion. If a very thin layer is coated on the plate, it may not be enough to coat the peaks of the protruding grains with the copying solution, and further treatment may lead to their becoming greased by the copying ink.

Coating the plate with chromated albumin can be performed in either a horizontal or a vertical centrifuge; each type has its own features.

If a horizontal centrifuge is used, it is started with a speed of 40-50 rpm and a measured batch of solution is poured over the plate in a uniform thin stream. The solution is poured from a laboratory beaker, covered with a 4-fold piece of wet (but carefully wrung) gauze. The solution is first poured on the center of the plate, and when it spreads over the plate and reaches its edge, the stream is moved from the center to the edge. Such a procedure results in a sufficiently uniform emulsion over the entire surface of the plate. After the necessary amount of solution is poured on the plate, the cover of the centrifuge is closed, the heating elements are turned on, and the plate is left to rotate at the same speed (40-50 rpm) until the emulsion is completely dried out.

If the plate is coated in a vertical centrifuge, all the solution is poured only on the center of the plate, the speed of rotation of the crosspiece is first raised to 50-60 rpm during the time of pouring, but after all the copying solution is poured on the plate, it is reduced to 30-40 rpm.

A plate covered with the chromated albumin and dried should appear dull. If the plate's surface is glossy, it indicates that the albumin emulsion is too thick. If the emulsion is too thin, the plate seems uneven and spotty.

When the copying solution is poured over the plate, it is necessary to see to it that the emulsion spreads uniformly, without bubbles and foam, for after it is dried such places remain uncovered and will become greased in the subsequent work.

It is possible to coat the chromated albumin on the surface of an aluminum plate in some cases without a centrifuge, or else to

perform only part of the operations in a centrifuge, and the remainder outside it. If a small part of the plate is coated (for example, to produce a screen), the chromated albumin can be coated with a rubber roller or with a gauze pad, with the operator requiring certain skill for the purpose. Copying emulsion coated with a roller or pad can be dried in the centrifuge or with the aid of a lithographic fan, blower, etc.

In certain cartographic factories a combined method of coating the chromated albumin is used. Small plates (up to 80 x 100 cm) are coated in the following manner: the moistened plate is held inclined (10-15°) in one hand, and the larger edge is coated with albumin poured from a laboratory beaker. After the solution reaches the opposite edge, the plate is turned by 180° and the solution is poured on the other side. The emulsion is first equalized by rocking the plate, which is then placed in a centrifuge and left there until it is dried at a speed of 40-50 rpm. This method involves a much smaller consumption of solution than the method used when pouring the solution in the centrifuge.

Correct illumination of the copying room is of exceedingly great importance. Until it dries, chromated albumin has little sensitivity to light. The dried-out thin film is light-sensitive in the short-wave part of the spectrum. It is insensitive even if dry to the long-wave part of the spectrum -- from the yellow to the red. Taking these features into account, all the operations with undried chromated albumin can be carried in relatively bright light, and the illumination need be restricted only after emulsion has dried out. Since all operations in cartographic factories are carried out as a rule in one room using the parallel assembly line

method, the illumination must be so chosen as to take into account the operating conditions with dried chromated-albumin emulsion.

The overall illumination of the room in which the copying operations are performed should be dark yellow or bright orange. At the same time, it must be sufficiently intense for visual control of the quality of the printing form. In view of the fact that the sensitization and exposure of the plate are performed as a rule in the same room, it is necessary to exercise elementary caution.

During the time that a plate is dried in the centrifuge, the cover of the centrifuge must be closed if another plate is simultaneously exposed in the copying frame. The cover can be open only when the arc lamps (or other sources of light for the exposure) are turned off. The sensitized plate removed from the centrifuge cannot remain in light even for a short period not only in natural daylight, but also in ordinary electric light, for incandescent lamps radiate actinic rays. The slightest hardening of the chromated albumin may cause the blank areas of the form to become greasy during the subsequent operations, thereby spoiling the plate, particularly when copying fine cartographic line work or a screen image. It is advisable to operate the bulbs at half the voltage, for example, use 220-volt bulbs on a 120 (110)-volt line.

The time interval from the instant of complete drying of the emulsion on the plate to its exposure in the copying frame should not be greater than required for "acclimatization" of the emulsion to the room conditions, i.e., to assume the temperature and relative humidity of the surrounding air. This usually lasts 3-5 minutes.

The dried film of chromate albumin is hardened not only by the action of the light, but also in darkness under the influence

of high temperature and even in ordinary temperature. True, this process is much slower than under the influence of light. In practice the time elapsed from the drying of the emulsion to the exposure must not exceed 30-40 minutes.

The exposure is greatly affected by the humidity of the emulsion that is coated (and dried out) on the plate. A dried emulsion requires more exposure than one containing a normal amount of moisture (relative humidity 60-65% at a temperature of 18-22°).

Also important is the temperature of the dried copying emulsion. The emulsion is dried in the centrifuge at 30-35°, and the temperature in the shop rarely exceeds 22-25° under normal conditions. The negative prepared for copying also is of the same temperature. If one places in the copying frame a cold negative over the warm plate, removed from the centrifuge, moisture will condense on its surface, and this may cause the emulsion layer of the negative to adhere to the layer of the chromated albumin, and to spoil the plate and negative.

28. Copying from the Negative to the Sensitized Plate

Correct exposure is of decisive importance for production of a high-grade printing form. The optimum duration of exposure is particularly important in map publishing, for a single negative frequently contains cartographic drawing elements of different character. Thus, for example, along with sufficiently thick lines of the drawing there are also fine lines or legends with fine elements of script or a series of fine lines, very close to each other. Finally, cases are encountered when the same negative contains line elements of different character and certain screen images. The

complication lies as a rule in the choice of the most suitable exposure for the fine lines that are close to each other on the cartographic drawing, and also for the screen images.

The duration of the exposure may fluctuate over a considerable range, for it depends on a very large number of factors, the influence of which is sometimes difficult to calculate beforehand. The exposure is affected mostly by the following factors:

1. Quality of the Negative. Negative with "open" line drawings, where the fog is insignificant in the transparent places (less than 0.2), requires less exposure, other conditions being equal, than a negative in which the line drawings are "contracted," where the fog reaches greater values (more than 0.2).

2. Intensity and Spectral Composition of the Illumination. The exposure is shorter if the illumination is more intense and longer if it is less intense. Even during a relatively short exposure, the intensity of illumination may vary, making it possible to effect a correct choice of the duration of the exposure. The spectral composition of the light is very important. Chromated albumin is sensitive only to the short-wave (green-violet) portion of the spectrum and is insensitive to the long-wave (yellow-red) portion. Various light sources radiate light of varying spectral composition. For example, incandescent lamps radiate more long-wave rays, while arc lamps, to the contrary, radiate shorter rays. Consequently, if incandescent lamps are used, a considerably greater exposure is required than if arc lamps are used. This is why arc lamps are used as the principal source of light for copying.

3. Distance from the Source of Light to the Light-Sensitive Emulsion. The closer the source of light to the light-sensitive emulsion, the more intense the beam that illuminates the negative, and consequently, the more illumination on the plate with its coating of light-sensitive emulsion. If the light source is constant, the illumination time is proportional to the square of the distance from the light source to the light-sensitive emulsion. In other words, if the distance from the light source to the light-sensitive emulsion is increased by two times, the exposure must be increased by four times, other conditions being equal, and, to the contrary, if the distance is reduced by two times the exposure must be reduced by four times. In practice this law is frequently neglected, and this affects the copying results adversely.

In practice, the distance from the light source to the emulsion is kept constant by using markers for the position of the counterbalance of the arc lamp or of any another light fixture used for the copying.

4. The duration of the exposure is affected by the thickness of the copying emulsion, by the ratio of colloid to bichromate in the light-sensitive solution, and also by the nature of the colloid. The moisture content in the emulsion is of substantial importance.

The great variety of factors affecting the duration of the exposure, and particularly the fact that many of these are not constant, makes it impossible to determine the exposure by calculation. The exposure, as a rule, is therefore determined experimentally (by producing a test copy). It is most convenient to employ for this purpose a negative of a line screen and copy

it by using a series of stepped exposures. The uniform field of the line screen on the form is most conveniently and simply compared with the screen of the negative so as to determine how accurately this drawing is transferred to the form. Taking into account that the usual exposure fluctuates from 3-4 to 7-8 minutes, the test scale can be copied at exposures of 4-6-8 or 3-5-7-9 minutes. Such a printing form makes it possible to determine the exposure time required to obtain good results under the given operating conditions (with the given emulsion, at the given illumination, humidity, etc) from a negative having the same type of optical qualities as the copy negative.

The copying results are affected by the character of the light source. In practice, there is seldom an absolute contact between the emulsion layer of the negative and the colloid film. This may be due to the uneven layer of pigment used to retouch the negative, barely noticeable defects on the surface of the plate that are hardly visible to the eye, and many other causes. The best results are therefore obtained by using so-called "point" sources of light, which are closely approximated by the arc lamp. If such sources of light are used, the influence of imperfect contact is at a minimum. But even with an ideal "point" light source (the arc lamp naturally is not such a source) one must not use very short distances from the source to the emulsion. The above is well illustrated by Figure 62.

If the light source is located at point A, the hardened portion of the chromated albumin will correspond to the dimension a, while at the sources at point B, it will correspond to dimension b. It is seen on the drawing that b is greater than a.

In practice, placing the source of light close to the emulsion causes a deepening of the printing elements and no subsequent treatment of the printing form can eliminate this. This factor is of particular importance in map publishing, where one must cope with fine line elements, which are close to each other. The instruction therefore prohibits distances less than one m between the light source and the light-sensitive emulsion. It is also undesirable to place the light source very close to the glass of the copying frame because of the resulting considerable and uneven heating over the entire area of the glass of the frame, of the negative, and of the plate.

The quality of the negative is frequently uneven over the entire field: some places on the drawing are "contracted" and some are "open." In such cases it is impossible to obtain an equally good drawing on the entire printing form with a single exposure, and the copy operator must therefore give different exposures to different parts of the negative. If the "contracted" place on the negative is localized, then a normal exposure is given to the entire negative, and then, without turning the light off, some opaque material (cardboard, black paper, etc) is used to cover all the normal parts of the negative, leaving the "contracted" place exposed to the action of light for some additional time. To equalize the exposure it is possible to shield the "open" places on the negative, by covering them, for example, with cigarette paper. Thus, with some skill, the copy operator can produce satisfactory results when copying from a negative that has a somewhat uneven drawing by cleverly varying the exposure.

In the preparation of ordinary original or machine printing forms, the copy operator must see to it that the drawing is correctly placed relative to the gripper line and to the center line. In addition to the simplest cases of copying of printing forms, one encounters in practice also more complicated cases, in which it is quite different to place the negative on the plate prior to the exposure.

From among the complicated cases of copying, let us consider registration copying employed in the following cases:

1. When elements of different originals, must be printed in the publication with the same color. An example are many maps, where both the hydrographic network and its legends are printed in one color (blue), but the hydrography is drawn on the line original, and the pertinent legends are pasted on the legend original.

2. When the original is photographed not as a whole, but in parts and the individual parts of the cartographic drawing are combined in a single printing form when copying.

3. If one color is used to print line and tone elements.

The most complicated case of registration copying is the superposition of a second negative on the plate. The registration of the drawing sometimes consumes much time, and this affects the quality of the printing form. This is why registration copying should be employed only in those cases, when no other methods can be used.

The most reliable way of effecting registration copying is subsequent copying of the image from different negatives in "phantom outline." Frequently the "phantom outline" is prepared not of the entire drawing, but of the corners of the inner frame and the image is copied within these markers. This method is usable only for simple diagrams, for example, in classroom wall maps. In the case of maps with complicated and fine drawings, requiring exact registration, the "phantom outline" should include the entire drawing. This is necessary so as to be able to check on the form itself the coincidence of the images, copied from the different negatives, and to choose not only the corner of the frame, but also other orientation marker for the registry (the intersection of the parallels and meridians, characteristic contours, etc).

Sometimes it is possible to dispense with the "phantom outline." It is possible, for example, to obtain a combined form of the hydrography and its captions in the following manner. The line drawings of the hydrography is first copied, after which the captions are copied relative to the corners of the frame. Here it is possible either to roll paint on the form and develop after the first copying, and to obtain the second copy to repeat on the same form the entire process from the coating of the light-sensitive emulsion to the development, or else after the first copying to produce with tusche a barely noticeable image in selected check points, which are used to register the second negative, after which its image is copied and then all the remaining operations are performed with the form.

No matter what method is chosen, it is necessary to see to it that the entire process from the instant of the drying of the film of chromated colloid to the development of the form is carried out in a minimum of time. It is therefore necessary to choose such a method, as to give the best qualitative results under the given conditions.

Unfortunately, very little account is taken in practice of the very important role that illumination has in the process of registering negatives. When fine elements from two and sometimes even three negatives are registered on a single form, this process may continue for a considerable time, and one must therefore not permit excessive illumination of the light-sensitive emulsion until the negatives are fully registered. In practice, the registry is frequently carried out in light from a portable incandescent lamp of high power. It would be most advantageous to employ bright orange or yellow lamps, or lamps operating at half voltage, and in the case of extreme necessity, incandescent lamps not stronger than 40 watts for a short time (2-3 minutes). Since the emulsion can become partly tanned under the lines of the drawing upon prolonged illumination or upon illumination with stronger lamps, this may lead to a loss in the sharpness of the drawing and to a general deterioration of the quality of the form.

29. Rolling the Copied Form with Ink

The inking is necessary to produce the printing elements. According to modern ideas, the printing elements on the photo-mechanical printing forms are formed because the fatty acids,

contained in the ink which is rolled over the plate after hardening, rapidly diffuse through the emulsion of the hardened albumin, and at the same time the diffusion through the emulsion of the unhardened albumin is difficult and is considerably slower. Investigations by V. S. Lapatukhin have shown that the greasing on the surface of the plate occurs within 1-2 minutes under the hardened copying emulsion and within 60-70 minutes under the unhardened one.

This indicates that a plate covered with ink must not be left inked for a long time, for its quality may deteriorate or else it may be completely spoiled owing to a certain (perhaps insignificant, but nevertheless exerting an extremely adverse effect) greasing of the blank elements. The time from the covering the plate with ink until its development must not exceed 5 minutes.

Various methods may be used to cover the plate with ink. The oldest methods, insuring high quality if skilfully handled, is to use a roller. If we take into account that the ink must lie over the entire plate in a uniform and thin layer (the plate covered with ink must be of dark-gray color), it becomes clear that this method calls for an experienced copying operator, well acquainted with the technique of rolling a form with a hand roller, and also requires much time. A simpler and faster method is one in which the ink is applied with a gauze swab and is merely evened up with a hand lithographic roller.

The coating of the copying form with ink has still another purpose, namely to facilitate visual control over the quality of

the form, for otherwise it would be impossible to determine the quality of the line elements until a print is made.

30. Development and Finishing of Copied Printing Form

The development of the form consists of removing the unhardened chromated albumin together with the ink on it from the plate. This removal must be carried out as carefully as possible so that no traces of chromated albumin remain on the surface of the plate in the nonprinting elements.

A printing form prepared by negative copying can be developed in two ways. The simplest way is to dip the form, with the ink rolled on, into a tray (or sink) with water and rub it lightly (without pressure) with a cotton pad. If no errors were made when the albumin was poured on the plate, if the light-sensitive emulsion was prepared exactly according to the formula, if the rules of illumination and drying of the emulsion were observed, if the exposure was normal, and if the negative was of good quality, the paint should readily come off the nonprinting elements and a dark gray or black cartographic drawing should appear on the surface of the aluminum.

Another way of developing, more complicated but giving better qualitative results if the copying operator has a certain amount of experience, consists of placing the plate with the ink rolled on for a few minutes in a tray with water after which with a pile roller is used to roll off the ink from the nonprinting elements together with the unhardened albumin. The best quality is obtained by developing the printing form in two stages. In the first stage the entire form is developed,

without processing each element completely. This is necessary to be able to remove the paint rapidly from as much a nonprinting area of the form as possible. During this stage of development it is best to rub the plate with a large cotton pad. In the next stage a small pad made of hygroscopic cotton is used to complete the development, particularly in places with dense and fine lines. During this stage the drawing is carefully rubbed with cotton and the entire form is inspected. The second stage requires great care and must be performed personally by the copying foreman, for the least nonprinting elements (the holes of the letters in the captions, bends in a complex shoreline, spaces between symbols with lines that are closely located to each other, etc) should be fully freed of ink and albumin. It is necessary to develop particularly carefully the screen drawings (for example, the wash-off relief).

Some enterprises use a piece of flannel or blanketing for development. This method must not be used, for when the form is rubbed the ink is removed not only from the nonprinting elements, but partly also from the printing elements, thereby weakening the latter.

The development of the printing form makes it possible to draw correct conclusions concerning its quality. During the development of the drawing, the printing form displays all errors and shortcomings produced during any stage of its preparation. These errors may be of all kinds and be caused by many factors, but all can be reduced to several groups, for which we shall list the principal factors that cause the error.

1. Ink does not come off well from the nonprinting elements upon development. If this fault occurs, the form is in most cases not suitable for printing and must be done over. Removal of the paint by vigorous rubbing with blanketing, cloth, or by treatment with ammonia and acids, does not lead to good results as a rule. If only a slight effort is needed to remove the ink from the nonprinting elements, it is recommended in the instruction that the plate be treated with a 1-2% solution of bicarbonate of soda to restore the quality of the form.

The ink does not remove well from the nonprinting elements or cannot be removed at all as a result of the following causes:

(a) Too thin a layer of chromated albumin, either because it is insufficiently viscous, or owing to too fast a rotation of the crosspiece of the centrifuge. It must be taken into account that if the layer of albumin is too thin, the harmful effect of incorrect temperature conditions becomes aggravated, as do the effects of incorrect drying conditions, shortcomings in illumination, insufficient optical density of the negative background, and many others.

The factor causing excessive thinning of the layer must be eliminated or else the plate must be poured on twice, with the latter being capable of producing the required results only if a horizontal centrifuge is used. Reducing the exposure time cannot lead to substantial results.

(b) The copying emulsion was dried at a temperature above 40%. Under such conditions the chromated albumin can become partially hardened within a short time even without the action of light, and thus absorb well the copying ink and facilitate its diffusion through the emulsion, and this is capable of leading

(and in practice sometimes leads) to the greasing of the non-printing elements, even though all the other operations with the form were performed correctly and carefully. This shortcoming cannot be fully eliminated with any supplementary treatment of the form. Although its effect may be hardly noticeable at the beginning of the printing, it may become aggravated during the printing of the run. The effect of this incorrect condition manifests itself specifically in a mottled appearance of the nonprinting elements, which cannot be removed readily from the form. Apparently hardening due to excessive temperature does not take place over the entire mass of the chromated albumin, but only in its individual spots (dots, etc), i.e., in individual crystals so to speak, in which a faster diffusion of the ink occurs.

(c) Insufficiently dense background of the negative. In this case, as a rule, it is impossible to obtain a sharp and fine drawing on the printing form; the edges of the drawing become fuzzy and so to speak washed out. This fault is difficult to eliminate in copying. To avoid it, it is necessary to check the negative carefully before copying begins.

(d) Not enough ammonia in the copying emulsion. The role of the ammonia in the copying solution has not yet been fully understood. Observations have established that it reduces the dark hardening of the emulsion and apparently contributes thereby to its protection against premature coagulation. The resistance of the layer to coagulation increases with the value of pH. Thus, it probably plays a double role: on one hand, introducing ammonia reduces the dark hardening and on the other, the presence of ammonia increases the pH of the copying emulsion. This is why

reducing the amount of ammonia in the emulsion may lead to "shadowing" of the printing form.

2. The drawing did not stay on the form or turned out gray. This shortcoming can be caused by the following factors:

(a) Too thick a layer of chromated albumin. Here, even at relatively large exposure, the printing elements of the form are not strong enough. Lines on such a form are usually gray and "broken." When they are rolled on they can be sometimes reinforced, but they are nevertheless weak and unstable in printing.

This results from the fact that the albumin was made too viscous or because the pouring on the plate was done with slow rotation of the crosspiece of the centrifuge.

(b) The lines of the drawing on the negative are accompanied by fog (optical density greater than 0.2). When copying from such a negative, it is as a rule impossible to obtain a good printing form. The line (printing) elements on the form are gray and have a large number of small breaks. Such a form can frequently be corrected by rerolling, but a good quality print is almost impossible to obtain with it. This shortcoming is also difficult to eliminate. It can be avoided only by thorough inspection of the negative before copying.

If the entire drawing on the negative is covered with fog or if large portions of the negative are fogged, the quality of the form can be improved somewhat by increasing the exposure of the entire negative or of individual (fog) parts.

(c) Too much ammonia in the copying emulsion. Many observations have established that increasing the pH decreases the light-sensitivity of the copying emulsion. It is possible that too much ammonia in the emulsion causes such a noticeable decrease in the sensitivity of the emulsion, that it is impossible to insure the necessary strength of the printing elements.

Thus, copying the negative produces the printing elements of the form. For the nonprinting elements of the form to be stable, it must specially treated, rerolled.

The carrier of the moisture, preventing the attachment of the ink to the nonprinting elements, is a layer of hydrophilic colloid adsorbed on the phosphate film of the metal. The hydrophilization of the nonprinting places indeed consists of forming phosphate films with colloid adsorbed on their surface, this being accomplished by treating a developed plate with the hydrophilizing solution (etching solution). The hydrophilizing solution is composed principally of hydrophilic colloid (mostly dextrin) and some mineral acids (most frequently phosphoric). The acid, reacting with the surface film, produces on the surface of the metal a stronger developed film of its phosphate, on which the colloid located in the solution is strongly adsorbed. A single treatment of the form by the hydrophilizer creates simultaneously a phosphate film and a layer of hydrophilic colloid that is adsorbed on it.

But this does not limit the role of the hydrophilizing solution. The fact is that a thin layer of chromated albumin, which may hinder the formation of stable nonprinting elements,

remains adsorbed on the metal (more correctly on the surface oxide film) on the nonprinting areas of the developed form.

Treating the printing form with the hydrophilizing solution eliminates this danger.

The printing form, which contains both printing and non-printing elements, is now suitable for printing in a press or in a printing machine. Before printing, the form is rerolled, i.e., the copying ink is replaced with transfer ink. This reinforces both the printing and the nonprinting elements.

In practice one employs two methods of rolling the form: "raw" and "dry." The first method is simpler and is used almost always for forms obtained by photomechanical means. The second is somewhat more complicated and is used in cases when the printing elements are weak and no strong nonprinting elements have yet been produced (principally to manufacture printing forms "by transfer").

In "raw" rolling turpentine is used to wash off the copying ink from the form that has been treated by the hydrophilizing solution and moistened, and the transfer ink, which contains more free fatty acids and which therefore reinforces the printing elements is rolled on the form with a roller.

In "dry" rolling matters are different. In those cases, when no stable nonprinting elements have yet been produced, and the printing elements are still quite weak, the task of treating the printing form becomes more complicated. One cannot grease the printing elements before stable unprinting elements have been produced,

for the latter may absorb the ink when the printing elements are greased. Nor is it possible to produce the nonprinting elements by treating them with the hydrophilizing solution, since this solution may also damage the still weak printing elements. Rolling "dry" makes it possible to solve this problem of reinforcing both the printing and nonprinting elements in several steps.

The plate is first covered with a thin layer of an aqueous solution of dextrin and is dried. The dextrin solution covers only the nonprinting elements. The printing elements are treated with lithographic tincture, which washes off the ink from the printing elements and simultaneously greases them. Such a treatment reinforces considerably the stability of the printing elements, without affecting the nonprinting elements, which are covered with a coat of dextrin. The plate is then rolled with the transfer ink, which adheres to the printing elements and to the layer of dextrin, which covers the nonprinting elements. The plate is then moistened and rolled with a pile lithographic roller. The layer of ink remains on the printing elements, but when the layer of dextrin on the nonprinting elements and the ink on it are moistened, they are transferred from the plates to the roller, thus freeing the nonprinting elements. By moistening and rolling the plate several times, all the dextrin and the paint on it are removed. After the nonprinting elements have been freed, they must be made stable, i.e., a layer of metal phosphate with an adsorbed layer of hydrophilic colloid must be formed at these places; for this purpose they are treated with the hydrophilizing solution.

Before treating with the hydrophilizing solution, the image on the form must be dusted with talcum powder, which adheres to the ink and protects the printing elements against the action of the acid that is contained in the hydrophilizer.

The finished printing form should be covered with a thin uniform layer of colloid, which protects it against mechanical action, and also against the influence of the surrounding atmosphere. Only a form coated with colloid can be stored. Most frequently dextrin (40% solution) is used for the purpose. The colloid is put on manually with a pad. The colloid should be put on in an even thin layer and immediately dried thoroughly. Sometimes the rapid drying of the layer of protective colloid placed on the printing form is neglected under manufacturing conditions, and this causes corrosion and certain other faults on the plates.

CHAPTER 10

PREPARATION OF PRINTING FORMS BY POSITIVE COPYING

Positive copying differs substantially from negative copying. In negative copying the hardened parts are carriers of the printing elements, but in the positive method they serve only as a protective layer for the nonprinting elements in the manufacture of the form. The printing elements (hardened chromated colloid) lie in negative copying on the surface of the plate, and in positive copying the printing element (a film of tar) lies at a certain depth. In the negative method the copying is from the negative, and in positive from a positive.

Technologically the process of manufacturing the printing form by the positive-copying method includes several operations, that are also inherent in the negative copying method, but in addition, it contains new processes: deepening the printing elements (etching), covering with lacquer, and removal of the hardened layer.

The production of a printing form by the positive-copying method on a prepared plate reduces to the performance of the following operations:

- (1) Preparation of plates for copying.
- (2) Pouring chromated colloid on the plate and drying.
- (3) Exposure through the positive.
- (4) Development of the image.
- (5) Deepening the printing elements (etching).
- (6) Correction of faults in copying.
- (7) Covering the plate with lacquer.
- (8) Covering the plate with ink.
- (9) Removal of the hardened emulsion.
- (10) Processing the plate to produce stable nonprinting elements.

31. Copying Emulsions for Positive Copying

Before we consider each of the operations individually, let us consider the materials used in this method for copying emulsions.

The most widely used of the natural colloids are resin from Siberian larch, gum-arabic, and their mixtures. Good results were obtained also in experiments with dextrin, casein, and other

materials. There has been a sufficiently reliable test of the possibility of using gelatine and other animal glues, which also gave favorable results. From among the synthetic colloids, quite satisfactory results were obtained with polyvinyl alcohol. Thus, there are various materials suitable for use as colloids in the positive copying method.

Comparative results of tests of various materials for use as colloids for the light-sensitive copying solutions, given in the work by A. A. Sinegub-Lavrenko [20] and later works, lead to the following conclusions.

A copying solution comprising a mixture of gum-arabic (35%) and albumin (85%) gives satisfactory results, exerts a sufficient protective action, and permits washing with water after etching. The copying emulsion is removed after treating the surface by 1-1.5% solution of sulphuric acid for 1-2 minutes and by brushing. The printing elements withstand such a treatment.

A solution of gum-arabic, which contains not less than 10-12% of the latter, gives good results. The emulsion is strong enough to be washed with water after etching. The plate need not be treated with acids to remove the hardened layer. After swelling in a bath for 5-10 minutes, the emulsion freely comes off the plate when rubbed with a brush.

Copying solutions of dextrin with a small addition of shellack make it possible to obtain a printing form in which the hardened layer can be washed with water. To remove it it is necessary to treat the form with acids.

Copying emulsions of gelatine give good results under the usual conditions used in copying only if hydrolized gelatine is used. These solutions can be washed in water after etching and make it possible to obtain a printing form for a map having drawings of any complexity.

Copying solutions of polyvinyl alcohol give good results if polyvinyl alcohol with a neutral reaction (pH of solution approximately 7) is used. When employing a polyvinyl alcohol giving an acid reaction, its solution must be first neutralized (for example, by adding a solution of soda).

Polyvinyl alcohol, being of synthetic origin, is of interest primarily because, having constant composition and constant physical-chemical properties, it can produce strictly repeatable results, and this is of exceeding importance for correct organization of the manufacturing process.

A hardened copying emulsion of polyvinyl alcohol affords sufficient protective action and permits washing in water. Such emulsions have higher light sensitivity compared with others and require less bichromate (ammonium or potassium) for chromation.

However, copying emulsions based on polyvinyl alcohol and have substantial shortcomings, namely; they form a strong adsorption film on the surface of the aluminum, which film makes the nonprinting elements hydrophobic. This film is difficult to remove from the surface of the form, even when treated with a 2-3% solution of sulphuric acid.

Attempts were made to employ a copying emulsion made of a mixture of polyvinyl alcohol and dextrin. However, this copying solution peels off rapidly. Favorable results were obtained by coating the plate with a substratum of dextrin before coating it with a copying solution made of chromated polyvinyl alcohol. Here the dextrin prevented the adsorption of the polyvinyl alcohol on the surface of the aluminum.

Emulsions of resin of Siberian larch are widely used in Russia and results in copying solutions that are suitable for reproduction of all types of originals.

Investigations at the Scientific Research Institute for Polygraphic Industry and Engineering have shown that if an ordinary calcium-chloride developing solution is used, the hardening of the copying emulsions made of chromated resin of Siberian larch is not strong enough and does not afford sufficient protective action during the preparation of the printing form. These emulsions give good results if the copies are treated with a solution of ammonium thiocyanate (instead of calcium chloride).

Emulsions made of a mixture of gum-arabic and resin of Siberian larch give satisfactory results, and permits washing the plate with water, and is relatively easy to remove from the plate.

An emulsion made of a mixture of resin of Siberian larch with apricot resin is used in the manufacture of original printing forms for small-scale atlases with fine line symbols and with small captions. The results obtained are quite acceptable.

As can be seen, there are many materials for the light-sensitive copying solutions used in the manufacture of printing forms by the positive copying method, and they can be suitably chosen for various manufacturing tasks and for different conditions.

The schedule of the technological process as a whole depends little on the nature of the colloid, differing for each colloid only in the individual operations and most frequently in the second-degree details and particulars.

32. Preparation of Plate, Coating the Copying Emulsion, and Exposure

The preparation of the plate, as in the case of negative copying, consists of cleaning its surface and graining it. Before coating the light sensitive emulsion, the surface of the plate is treated in addition with a 1% solution of sulphuric acid, so as to destroy the oxide film formed on its surface, thereby facilitating the subsequent formation of the printing elements.

The copying emulsion is coated in the same manner as in the case of negative copying. When pouring on the emulsion it is important to distribute the emulsion evenly and to avoid all foam or bubbles. If a horizontal centrifuge is used, the pouring should be at a speed of 40-50 rpm, and after the required amount of solution is poured on the plate, its speed is reduced somewhat (to 30-35 rpm). A slight slowdown of the speed of the centrifuge after coating the plate with the copying solution is necessary to avoid excessive discarding of the emulsion from the plate.

The GUGK instruction recommends that the following amounts of solution be poured on the plate:

For 120 x 140 cm plates	400 milliliters
For 110 x 120 cm plates	300 milliliters
For 90 x 110 cm plates	250 milliliters
For 50 x 60 cm plates	100 milliliters

Experience has shown that it is best to pour the copying solution on the plate in a horizontal centrifuge using the following procedure: the solution is poured on the center of the plate from a laboratory beaker; when it has spread on a greater part of the plate, a thin stream of solution is transferred from the center of the plate to the edge. After having poured half of the required solution in this manner, the steps are repeated. When working with copying solutions made of gelatine (non-hydrolyzed) or of woodworking or any other bone glue, it is necessary to heat the plate and the solution, since a solution of gelatine or of other bone glues congeals at a relatively high temperature (gelatin at 29, wood-working glue at 19° etc). It is therefore necessary to heat both the solution and the plate before pouring (to a temperature of approximately 35°) so that the solution distributes itself uniformly on the plate.

Exposure Through the Positive. The exposure is made in the copying frame through the positive. This should cause the nonprinting spots to be hardened and the drawing to remain unhardened.

To obtain a printing form of high quality, the drawing lines on the positive should be opaque and sharp, and the background (nonprinting field) should not be fogged. It is impossible to obtain a good printing form from a positive that does not satisfy

these conditions. In rare cases a printing form can be obtained from a positive having a slightly fogged background. The possibilities of correcting shortcomings of the positive by partially shielding it during the exposure time are limited.

As in the negative method, the exposure is determined experimentally. For example, if arc lamps are used for illumination and if the source of light is 1 m away from the plate, the exposure time is 8-12 minutes, depending on the quality of the positive. Too short an exposure does not insure a sufficiently stable hardened copying emulsion during the development process, leading in practice to a condition where the film does not remain on the plate upon development and causing the stripping of the nonprinting elements, or else it is necessary to employ incomplete development for fear of ruining the emulsion, and this makes difficult the formation of the printing elements. In either case it is impossible to obtain a satisfactory printing form.

Too long an exposure causes the particularly thin elements to become overprinted owing to diffuse scattering of light in the emulsion, and the development of these locations becomes difficult and cannot be brought to a conclusion, causing the printing elements to be of low quality. It is impossible to obtain a good printing form in the case of exposures that are either too long or too short.

33. Development and Deep Etching of Image

In the case of positive copying, the image (line, strokes, and dots, comprising the cartographic drawing) is not hardened.

To produce at these locations strong printing elements it is necessary to undercut the metal under these places. In the transfer method and in the case of negative copying, the printing elements are formed as the result of adsorption of fatty acids on the surface of the form material, and these acids are contained in the transfer and copying inks, in the lithographic ink, etc. The substantial difference in the case of positive copying lies in the fact that the printing elements are formed on a thin film of tar (film of the so-called lacquer) intermediate between the plate and the printing ink.

In positive copying the development is required to eliminate from drawing the colloid coating -- a necessary condition for the formation of the printing elements.

Developers. The simplest developer is water. But water, which dissolves and carries away from the plate the unhardened colloid from the drawing, damages at the same time, to a greater or lesser extent, also the hardened colloid on the nonprinting spots. In most cases, therefore, one employs not water but a saturated aqueous solution of hygroscopic salts. When working with emulsions of gelatine or other bone glues, the developer can consist of water alone.

The hygroscopic salt contained in the developer binds the water and does not permit it to damage the hardened colloid, at the same time not preventing the dissolution of the unhardened colloid. Up to recently the salt used in most developers was calcium chloride (CaCl_2).

After the drawing is developed with a solution of calcium chloride, a thin film of adsorbed colloid remains on the surface of the plate. If this film is left, it will prevent formation of printing elements that turn out to be unstable under the influence of moistening and mechanical action and may become damaged during the printing process. To prevent this, and also to accelerate the process of removal of the unhardened copying emulsion from the plate, the developer contains not only water and calcium chloride, but also small amounts of weakly-dissociating organic acids. The most widely used is lactic acid, but acetic and others can also be used.

Thus, the developer is always composed of water, calcium chloride, and one of the organic weakly-dissociating (low-activity) acids.

Laboratory investigations performed at the TsMIGAIK have shown that a developer containing lactic acid, by dissolving and carrying away the unhardened colloid film reacts incidentally with the metal and apparently dissolves it somewhat. Thus, for example, chemical analysis has shown that an exhausted developer made with lactic acid contains zinc after it is used to develop a printing form made of zinc. The suggestion that a developer containing acids does not leave any colloid film on the printing elements was confirmed by work performed at the NRECh with forms having very complicated and fine line drawings (maps of World's Atlas) and with screened wash-off relief drawings photographed through a 40 line screen. In hundreds of printing forms, stable printing elements could be formed by development alone (first development), without requiring deepening of the printing elements (second development).

In those cases when the entire process of preparation of the form is carried out correctly, the printing elements turned out to be sufficiently strong and stable. In individual cases, when the first copying did not yield a high quality, the cause has always been the damage occurring during the performance of the process or during the preparation of the compound. One cannot therefore give much credence to the statement that if a plate is developed with a developer containing acid, a colloid film, preventing the formation of the printing elements, remains on the surface of the metal. Such a film can remain only in those cases, when the developer used is water or a solution of hygroscopic salt (for example, calcium chloride) without acid.

Along with developers, consisting of solutions of hygroscopic salt with a small amount of low-activity acids, one has been employing recently to a large extent developers the principal components of which is ammonium thiocyanate (NH_4CNS). Ammonium thiocyanate, as any other salt of thiocyanic acid, is a good peptizer and at the same time a cheap and readily available product, and this is the reason for choosing this particular material. If ethyl alcohol or glycerine are introduced into an aqueous solution of this salt, the damaging effect of such a solution on the hardened colloid is substantially reduced, while the developing action on the unhardened portion does not become the worse for it. This is why the developer employed now is composed of aqueous solution of ammonium thiocyanate and glycerin. A. L. Rozenblatt recommends the following developer formula for work with aluminum:

Glycerine (spec. gravity 1.18)	800 ml
Ammonium thiocyanate in solution (300 g in 700 ml of water)	200 ml

The specific gravity of the finished solution is 1.16.

Experiments carried out to improve the action of the developer with ammonium thiocyanate have shown that this developer gives good results, permitting in particular an accurate maintenance of the gradation scale in the reproduction of screen images. As indicated above, the use of ammonium thiocyanate has made possible extensive use of resin of Siberian larch as the colloid.

Many instructions recommend the development be carried out with a velvet or velour pad. Practical experience has shown that it is also possible to develop by rubbing the plate with a dense brush having fine hairs. When working with forms of maps containing very fine line symbols, development with a brush gives better results than with velvet or velour pads. The development procedure remains the same as that with a velour pad.

The required amount of developer is poured on a blank area (containing no drawing) of the surface of the plate, and a brush or pad are used to spread it over the entire surface. The plate is then treated with the developer by brushing in circular movements over the entire area containing the drawing. The development process first uncovers the metal, and the drawing acquires thereby a characteristic silver shade (it should be watched with a strong magnifier). Later on, upon further treatment of the form with the developer, the metal becomes somewhat darker, and this indicates that it has reacted with the developer.

The development must be carried out to conclusion, for this is a vital process. The hardened emulsion may brighten considerably during the development, for the water or the aqueous solutions

wash out a certain portion of the chromate salts from it. This sometimes causes the copying operator to stop the development too early, for fear of damaging the hardened copying emulsion, which is located on the nonprinting spots. Yet an insufficiently developed form cannot be of high quality; the colloid film remaining on the surface of the metal and not removed with the developer will prevent the formation of strong printing elements regardless whether only a single development is used, or whether the printing elements are deepened. In the former case the colloid film will prevent strong attachment of the coating of lacquer (more correctly, tar) on the metal, and in the second place the printing elements will not be capable of becoming deepened at these places, since the alcohol solutions (which are used in most cases in the form of alcohol solutions of ferric chloride) cannot dissolve the dried-out film of aqueous solution of colloid. From this point of view, development with a brush gives more reliable results, making it possible to employ somewhat longer exposures than usual, and this is very important to retain the strength of the hardened emulsion. At the same time, it makes it possible always to lead the development process to conclusion, without damaging the hardened copying emulsion, which protects the future nonprinting elements.

After development, if development alone is to be used without deepening, the plate should be well washed with water. Before washing, a clean gauze or cotton pad is used to remove excess developer. Washing is best performed in a centrifuge with the crosspiece rotating at a speed of 40-45 rpm, with a hose, or through a watering can. When the hardened copying emulsion is

washed, it brightens noticeably and quite rapidly, for the colloid chromate salts are washed out. This sometimes leads to premature stopping of the washing, something that should not be permitted. Washing should be done with not less than 6-8 liters of water poured on the plate.

If the production of the printing form is restricted only to development without etching the plate must be dried thoroughly after development in the same centrifuge. If the development is followed by deepening of the printing elements, then, without washing, the plate is subjected directly to further treatment.

Based on the work performed at the NRECh on the World Atlas, on the Small World Atlas, on the Marine Atlas, etc, it is possible to conclude that for small-runs and for original printing forms it is enough merely to develop, without resorting to deepening of the printing elements. If, however, it is necessary to print a considerable run from the printing form (1,000 copies and more), the printing elements must be deepened.

The usual flat printing form suffers from many substantial shortcomings, one of which is the thickening of the printing elements during the printing of the run. The positive-copying methods, owing to the possibility of deepening the elements, makes it possible to eliminate this serious shortcoming of the printing form entirely. To print large runs, and particularly, in the printing of fine line cartographic drawings, the deepening of the printing elements is therefore essential.

Deepening of the Printing Elements. Deepening of the printing elements (etching, or second development) is carried out to produce reliable printing elements during the further processing of the form, and to obtain a printing form that makes it possible to retain a sharp and saturated very fine cartographic drawing when printing maps in large runs.

On the printing elements of a form manufactured by the positive-copying method, the ink, as will be seen below, is placed on a thin film of lacquer (more correctly, tar), which is well fixed in the depressions of the printing elements and which holds the printing (greasy) ink strongly on its surface. Since the lacquer film lies in the depressions, the printing elements are protected during the preparation of the printing form and during the printing against mechanical damage and against the action of acids used during the treatment of the printing forms.

In addition, the printing elements located in the depressions make it possible to obtain prints with sharp edges of all the lines, even of the finest ones, a particularly important factor in map publishing.

Thus, the deepening of the printing elements plays a very important role in the production of the printing form, and careful performance of this process therefore affects to a considerable extent the quality of the printing form.

Deepening the printing form causes the metal to become dissolved and removed, and therefore this process is also called etching. At the same time the reaction between the etching compound and the metal forms in the depressions an oleophilic surface

which adsorbs well the tar films that serve as the base for the printing elements.

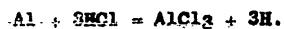
The deepening of the printing elements, or etching, can occur correctly only if the development of the drawing is fully completed. If the drawing is not fully developed and colloid remains in some individual parts, there will be no deepening of the printing elements in those places, and the printing elements will not turn out to be strong.

Etching (deepening of the drawing) should be rapid. Usually this process lasts 2-3 minutes and not more than 5. Longer etching may lead to a deterioration of the quality of the line elements of the map, particularly in such places as the fine double lines of roads, fine lettering with complicated drawings and hatchings, etc, in view of the fact that the etching compound reacts with the metal not only in depth, but also sideways, thereby deforming the printing elements.

The operating procedure of deepening the printing elements is analogous to the procedure used in the development. The etching compound is poured where possible on areas that have no drawing, and is then spread over the entire drawing, rubbing the latter, and at the same time the metal darkens at the places where the deepening takes place. When working with zinc this process is quite violent as evidenced by the fact that the etching solution is very rapidly covered with a very fine foam; it is gentler on aluminum, but is rapid there too.

In most cases the etching compound is composed of ferric chloride and alcohol, glycerin, and hydrochloric acid. The basic

reagents are ferric chloride and hydrochloric acids which react with aluminum to form compounds that are readily soluble at the etching compound, and consequently are readily removable from the surface of the plate. For hydrochloric acid, for example, this reaction can be represented by the equation



An alcohol solution is used in the compound so as not to harm the film of the hardened colloid, which protects the non-printing elements of the printing form against the lacquer and ink, and which otherwise would be noticeably weakened in the development process. The glycerine is introduced as a buffer liquid to slow down the reaction and to cause it to proceed more evenly.

A compound for deepening the printing elements, composed of ferric chloride with hydrochloric acid, was the most widely and universally used up to recent times. At the present time other compounds are being proposed, which give satisfactory results. In particular, A. L. Rozenblatt suggested for aluminum a compound, consisting ammonium thiocyanate and caustic alkali (potassium or sodium hydroxide), made up in accordance with the following formula:

First solution:	ammonium thiocyanate	400 g
	water	600 ml
Second solution:	potassium or sodium hydroxide	200 g
	water	200 ml

Both solutions are mixed together.

The working compound is made up of 500 milliliters of a mixture of the two solutions, to which 500 milliliters of glycerine (specific gravity 1.22) are added. The specific gravity of the finished compound should be 1.17-1.18.

After deepening the printing elements, the form should be thoroughly washed so as to remove the remnant of the etching compound and of the reaction products, which may prevent the adhesion of the lacquer in the depressions of the printing elements.

The washed form must be thoroughly dried, for even an insignificant amount of moisture will prevent the lacquer from adhering to the metal, owing to the tar dropping out from the solution, and no strongly fixed tar film will produced there, meaning that there will be no printing element. Furthermore, even the water that is capillary bound to the surface layer of the depressed printing elements may exert a harmful influence. The plate must therefore be heated during drying.

34. Coating with Lacquer and Ink

After the form is washed and dried, it is possible to coat it with a layer of lacquer. Certain specialists believe that after etching the printing element there is no particular need for special film for the formation of the printing elements. Practice has shown, however, that to print long runs the printing elements obtained on a layer of lacquer are stronger than those obtained without.

The lacquers used for the manufacture of printing forms by positive copying are solutions of certain tars in suitable solvents.

There is a large number of various recipes for lacquers, and all give good results. A lacquer that is very suitable for work and that is cheap is the one proposed by TsNIIGAIK, which consists of a solution of bakelite in a mixture of ethyl and butyl alcohol. Many tars have the property of being strongly adsorbed on the form material, and in addition, are capable of adsorbing surface-active substances. They can therefore serve as the base for the printing elements. In addition to bakelite, shellack and other substances have similar properties. After evaporation of the solvents from the lacquer layer, a thin film of tar remains on the plate.

The lacquer cannot be coated on a warm plate, for rapid cooling of the latter will cause considerable evaporation and condensation of the vapors in the form of minute droplets under the lacquer layer, which will prevent strong adhesion of the lacquer to the metal.

If small runs are printed on hand and machine presses (for example, line and color proofs) and if the printing elements are definitely etched, it is possible to dispense with the layer of lacquer. In this case the sensitizing action of the ferric chloride is quite adequate for the production of strong printing elements. The absence of a lacquer layer, which coats not only the printing elements that are free from colloid, but also the hardened copying emulsion located on the nonprinting elements, facilitates the removal of the latter. If, however, the printing elements are not etched, the layer of lacquer must be put on, for development alone cannot insure sufficient strength of the printing elements.

The lacquer is coated in a thin and uniform layer with the aid of a gauze pad. The equality of the thickness of the layer and the evenness of its distribution over the entire plate depends on the viscosity of the lacquer and on the volatility of the solvent. If the lacquer is too dilute, it does not produce a tar film of sufficient thickness, and the film can become damaged during subsequent handling of the form. Too thick a lacquer is difficult to coat in an even and thin layer on the plate. If the solvents are too volatile, it becomes difficult to coat the lacquer, particularly on plates of large dimensions, because the lacquer becomes rapidly condensed and cannot be distributed uniformly.

Before the plate is subjected to further treatment, the film of the lacquer (more correctly, tar) should be thoroughly dried. The solvent should be removed as much as possible. For this purpose it is best to dry the plate after coating with lacquer in a centrifuge with forced heat.

After the plate is dried, it should be gradually cooled before the coating of ink is placed on it.

The ink should be coated in an even and thin layer, for it acts as the direct printing element and inking the image makes it possible to control visually the quality of the line drawing.

In positive copying there is less danger than in negative copying of greasing the nonprinting elements with the ink, for the surface of the metal and the ink are separated not only by a layer of colloid, but also by the lacquer. Many authors

therefore recommend that inks containing a maximum amount of fatty acids be used, and Yu. I. Zolotnitskiy [2] recommends a tincture for this purpose. The instruction recommends an ink of the following composition:

Red illustrator's or offset ink	100 g
Transfer ink No 82	100 g
Rectified turpentine	100 ml

The procedure followed in coating the ink are the same as in negative copying.

After coating the form with ink it should be dusted with talcum powder and the hardened colloid, which protects the nonprinting elements during the time of preparation of the form, should be removed from its surface. At the same time the layer of lacquer and ink is also removed from the plate.

The hardened colloid is removed from the surface of the form with running water or in a tray. This method, however, is applicable not to all colloids, but only to certain ones, particularly gum-arabic, resin of Siberian larch, and their mixtures. The plate is rubbed at the same time with a hair brush at some pressure. When rubbing the plate it is necessary to see to it that the printing elements are not damaged. It is sometimes necessary to soak the layer before brushing in a bath with warm (50-80°) water. This facilitates the subsequent removal of the layer.

In the case of many colloids (polyvinyl alcohol, etc), brushing is not enough even in warm water. In those cases, it is necessary to use a weak solution of some mineral acid to remove the hardened copying emulsion.

Most frequently one employs a 1-2% solution of sulphuric acid. In this case the acid does not affect the printing elements, for they are covered with a coating of lacquer and ink, and the latter is dusted with talcum, which adheres to the ink and produces a good acid-resisting film.

The form is then treated so as to hydrophilize the nonprinting elements. This operation is carried out in the same manner as in the treatment of the printing form obtained by negative copying.

CHAPTER 11

OTHER METHODS OF PREPARING PRINTING FORMS

35. Preparation of Printing Forms by Direct Greasing the Surface of the Form Material

This method is used in the industry to prepare printing by the so-called "transfer" method, i.e., by printing the drawing on a prepared plate in the same way that prints are made on an offset press. The process consists of the following principal operations:

- (1) preparation of surface of plate;
- (2) application of the image;
- (3) fixing the printing elements.

Preparation of Surface of Plate. Before the drawing is coated on a plate, its surface must be cleared of dirt and must be sensitized, i.e., it is necessary in the given case to impart to the plate an increased sensitivity to the greasy transfer ink.

The surface of an aluminum plate can be cleaned by treating it with a pad moistened in a 1% solution of sulphuric acid for 1-2 minutes.

For a long time the image used to be applied manually with the aid of special grease-containing materials (lithographic tusche, lithographic pencil, etc). The image applied in this manner was weak, of low endurance, easily damaged in printing, and did not permit treatment of the plate by actively acting hydrophilizing solutions, necessary for the creation of stable blank elements. If the drawing applied to the plate is to adhere strongly to the surface of the plate it is necessary to sensitize it to materials containing fatty acids.

Sensitization consists of treating the aluminum plate with a 2-3% solution of ferric chloride, to form on its surface a residue of ferric oxide hydrate, having clearly pronounced oleophilic (hydrophobic) properties. A greasy drawing applied to such a surface is kept on it stronger and makes it possible to hydrophilize the nonprinting elements reliably.

Now that manual methods of applying the image with the aid of such materials as lithographic tusche have given place to mechanical methods employing other materials containing more free fatty acids, the need for sensitization of the aluminum plates has diminished and such plates are rarely treated with ferric chloride.

Application of the Image. The required drawing is applied to the previously prepared plate by indirectly greasing the form material; this is done, as indicated, by producing a so-called

transfer drawing with an offset press, which prints the image from the original printing form to the surface of the form material. The result is a new printing form (original form or machine form). The printing elements obtained in this case are weak, incapable of resisting mechanical wear and chemical action of the electrolyte contained in the hydrophilizing solutions. In addition, the drawing is as a rule uneven, does not produce a solid oleophilic (or hydrophobic) layer on the printing elements, and is so to speak "gray." It is impossible to print a long run from such a form. To make the form suitable for printing, the printing elements must be fixed, i.e., it is necessary to reinforce the adsorption of the film of fatty acids on the surface of the metal and to make it solid (dense).

To fix the printing elements, the transfer ink, with which the drawing is usually transferred, is washed off with lithographic tincture, which dissolves the ink and rids the surface layer of the film of fatty acids fixed by adsorption to the plate and at the same time intensifies their adsorption, thus fixing the printing elements. When the transfer ink is again rolled on the form that has been treated with the tincture and the excess removed, the ink forms a dense layer, producing reliable printing elements.

Since treating the transfer with tincture may cause greasing of not only the printing elements, but also of the unprotected nonprinting elements, the rolling must be performed "dry."

The hydrophilization of the nonprinting elements must be carried out only after the printing elements have been fixed by the usual method with the compounds normally used for the purpose.

An improved method of preparing printing forms by greasing ("transfer") consists of fixing of the printing elements with a layer of lacquer. For this purpose a layer of lacquer is placed over the surface of the printing elements which has been washed with tincture (with "dry" rolling) with a pad, the same as in the preparation of printing forms by the positive copying method, and after this the transfer ink is coated over the lacquer and the printing form is then processed in the usual manner.

A layer of lacquer, which adheres strongly to the plate and which holds the transfer or printing ink, makes the printing elements stronger, and makes the printing form suitable for considerably greater runs.

CHAPTER 12

PREPARATION OF NEGATIVES AND POSITIVES ON CHROME-COLLOID EMULSIONS

All photographic emulsions contain silver salts in greater or lesser amounts. The images form on them as a result of reduction of the finely-dispersed metallic silver. But silver is a valuable metal, and therefore the use of silver-containing photographic emulsions should be reduced to a minimum and silver should be replaced with other materials.

So far it is impossible to dispense entirely with the use of photographic emulsions containing silver. The initial negative must be prepared by one of the usual photographic methods, but the duplication of the negatives and the preparation of positives can be effected without photography for maps of the largest size and of any complexity.

Experience in the work of the NRECh has shown that the use of silverless emulsions on maps, each sheet of which measures up to 90 x 110 cm (wall maps for higher learning institutions), on maps with a fine cartographic drawings (general geographic, political, historical, and the special maps used in the second edition of the Great Soviet Encyclopedia) and on the maps of the second volume of the Marine Atlas has fully justified itself.

In the development of methods of using silverless emulsions for the preparation of negatives and positives, many attempts were made to photograph directly on these emulsions; these attempts, however, did not give favorable results. This is why silverless emulsions are used only for contact duplication of negatives and diapositives, the initial negative being obtained by photography on silver-containing photographic materials.

The methods of preparing the negatives and positives using chrome-colloid emulsions was developed in the institutions of the VTS and was adopted widely from there in cartographic production.

The different versions of the technological processes are determined by the different properties of the dyes employed: in one case a negative is obtained from a negative, and in others a positive is obtained from a negative. Of all the published methods for the use of silverless emulsions for contact preparation of negatives and diapositives, the most significant in map-publishing practice are wash-off relief and the selective coloring methods.

36. Wash-Off Relief Method

This method is based on the use of dyes that are capable of coloring hardened colloids, making it possible to obtain a positive from a negative and vice versa. The colloid employed is gelatin.

The method consists essentially of exposing a light-sensitive (copying) emulsion through the negative (or positive). After the exposure, the unhardened emulsion is dissolved and removed from the surface of the base, on which a hardened emulsion remains. The latter is colored and after washing, it forms the image. In those places where the emulsion was not hardened, only the base (glass, film, viniprox, etc) remains. Thus, it is possible to obtain a positive from a negative and vice versa.

The technological process consists of the successive performance of the following operations:

- (1) preparation of base;
- (2) application of light-sensitive (copying) emulsion;
- (3) exposure;
- (4) dissolution of the unexposed colloid and its removal from the surface of the base;
- (5) coloring the image;
- (6) washing the copy and its preparation for further operations.

The preparation of the base varies with its character. In all cases the surface of the base is cleaned of dirt, particularly fats. Viniprox (and also astralon and similar materials) and used photographic film are treated in a 1-2% solution of sulphuric acid. The solution is poured on the treated surface and rubbed for 2-3 minutes with a brush, after which it is rinsed in water.

Glass is prepared in the same way as for the wet-colloid method. It is important to see to it that the surface of the base be clean, for even the least amount of dirt can cause spoilage. Of all types of bases used in the work at the MKKCh (glass, viniprox, astralon) best results are obtained with glass. Glass holds the copying emulsion securely, does not warp when exposed to warm solutions, and does not become deformed, and can therefore be recommended as the best base for the preparation of negatives and positives by the wash-off relief method.

Coating the Light-Sensitive (Copying) Emulsion. The light-sensitive emulsion employed is a solution of hydrolyzed chromated gelatine, which is heated to 30-35° C and poured on the glass plate. For the emulsion to spread evenly, the plate is also heated (warm water is poured over it before the copying emulsion is coated).

The emulsion is coated in a centrifuge [whirler] with the crosspiece rotating at 15-20 rpm, using the same steps as employed in negative or positive copying. After the solution is uniformly distributed over the plate, the speed of rotation is increased to 35-40 rpm, the heaters are turned on, and the plate is left until the emulsion is thoroughly dry.

If the centrifuge is equipped with a net, the glass can be placed directly on the net. If there is no net, an aluminum sheet is placed on the crosspiece, and the glass placed on the aluminum.

When pouring it is necessary to see to it that the solution is spread uniformly, for an uneven thickness of the light-sensitive

emulsion calls for a variable exposure, and this cannot be done. Before pouring, the solution should be filtered to remove dirt particles, coagulations, and other inclusions that may affect the quality of the copy. It is necessary also to see to it that no bubbles remain on the surface of the plate when pouring, for these can also spoil the image.

When drying the plate, the temperature in the centrifuge must not rise above 35-40° C, for a higher temperature may lead to thermal hardening, capable of spoiling the plate. Even insignificant hardening will make it impossible to remove the gelatine completely from the plate during the subsequent treatment, and the remaining gelatine will be partly colored by the dye, forming fog. Similar results occur upon prolonged (more than 2 hours) storage of the prepared plate at ordinary temperature, for dark hardening comes into play then. During the drying, and particularly after drying, the plate must be protected against daylight or bright electric light, to prevent partial hardening of the emulsion.

When working with large size glass (more than 50x60 cm) special measures must be taken to attach the glass securely to the crosspiece. The light sensitive emulsion must be coated in a horizontal centrifuge.

After the plate is thoroughly dried, it should be cooled to the temperature of the surrounding air and acclimatized in the surrounding medium.

There are many various formulas for copying emulsions, differing from each other in their components and in their quantitative

relationships. The last part of the book contains formulas that have proved themselves in many projects performed at the MRECh.

Exposure. To obtain a high grade positive, the background of the negative must be dense, permitting no copying through, and guaranteeing against the possibility of even slight hardening of the copying emulsion; the lines of the drawing on the negative should be transparent. If the negative contains "contracted" places, they should be freed of fog (for example, by reduction). The transparency of the lines is needed to insure uniform and reliable hardening of the drawing in all parts. In places where the hardening is insufficient (under fogged parts of the drawing), the drawing can be damaged upon dissolution and removal of the unhardened colloid. In all cases when there is doubt or where there is a choice to be made, the following rule must be followed: the better results can be obtained with a more "open" negative.

The requirements governing the production of a negative are, to the contrary, that the background of the positive be as transparent as possible and pure, and that the drawing be as dense and opaque as possible.

In those cases when the copying is on a certain plastic material (viniproz, astralon, celluloid film, etc), the copying is best performed in a copying frame. If copying is from glass to glass, it is best to do it outside the copying frame.

The copying in the frame is carried out the same as in negative or positive method of preparing printing form, the only difference being that instead of aluminum (or zinc) plates one

employs a plastic material covered with a light-sensitive emulsion. When copying from glass to glass, if no frame is used, good contact must be provided between the two glasses, and it is therefore possible to use only well polished glass, the best being the plateglass used for mirrors. In this case the copying (exposure) is best performed with the glass plate removed from the copying frame. The prepared glass plate, with the light-sensitive emulsion up, is placed on the glass from the copying frame, and its emulsion side is placed in contact with the emulsion side of the negative (or positive), the pressure of which, if the plate is 70x80 cm or greater) will produce the required contact. If glass of smaller size is used, the negative must be covered from the top with a large clean glass.

The duration of the exposure depends on many factors, and it is therefore selected experimentally, best of all with a stepped exposure scale.

When negatives and positives are prepared by the wash-off relief method, the diffused scattering of light causes the colloid to be hardened in the emulsion not only in depth, but also sideways. If the positive is made from a previously made (for example, wet-collodion) negative, this causes the drawing on the positive to become somewhat thicker, and this phenomenon is more noticeable in the preparation of a negative from a positive than vice versa. This is why negatives prepared by contact with the wash-off relief method from a positive, which was prepared in the same manner, differ as a rule from the original negative in having a finer and sharper drawing.

The reflection halo may exert a harmful influence. To avoid or to reduce its influence, a sheet of black paper is placed under the plate.

Before exposing the plate, it is necessary to see to it that the prepared plate and the negative (or positive), from which the copying is to be done, have been sufficiently acclimatized under shop conditions. Otherwise moisture will condense on one of the surfaces, and this may lead to spoilage.

After exposure the drawing darkens and is quite noticeably different from the unexposed portions.

Solution of Unexposed Colloid and its Removal from the Surface of the Base. As indicated above, the wash-off relief method is based on the use of dye solutions, which are capable of coloring the hardened colloid, in this case gelatine. The unhardened colloid is quite unnecessary and should be removed from the plate. The latter is accomplished by dissolving it.

The hardened film of chromated gelatine, coagulated under the influence of the light, has lost its property of becoming dissolved not only in cold water, but also in warm water (30-40° C). At the same time, the unhardened film still retains fully this property. Therefore, if the exposed plate is treated with warm water, all sections of unhardened colloid which were not subjected to the action of light will dissolve, and consequently, will be removed from the surface. The hardened parts of the colloid remain on the surface of the plate, forming a relief image that so far is hardly noticeable.

This operation is carried out in a tray. After exposure, the plate is dropped into a tray, filled with warm water (35-40° C), and left there for 6-8 minutes. This time is enough to dissolve the unhardened emulsion. For the dissolution to proceed uniformly over the entire surface of the plate, the tray is rocked all the time.

Dyeing the Image. The image obtained as a result of the exposure is dyed so as to impart to it the optical density required for further copying work. The plate freed of the unhardened colloid is immersed in a tray with a dye solution for 5-7 minutes with constant rocking, so that the coloring of the image is uniform. From time to time the glass is raised and the intensity of the coloring is inspected by looking through it. Formulas for the dyeing solution, given in the last part of the book, give quite reliable results, as evidenced by the work performed at the MRKCh.

Washing the Copy and its Preparation for Further Work. After the dyeing process is finished, the copy must be washed. Washing should be thorough and prolonged, to free the transparent places of the copy from dye fully. The copy must be washed in running water not less than 15-20 minutes. It is best to wash it in the same manner as the wet-colloid negatives. It is necessary to wash both sides of the plate, and the reverse side (the glass side) must be rubbed with gauze or cotton until the dye is fully removed.

After washing, the copy should be covered with a coating of protective lacquer the same as in the preparation of the wet-colloid negative. The protective coating is necessary because

the film obtained (usually on the negative) is weak and may be easily damaged in the subsequent handling of the negative.

The negative (or positive) covered with the protective coating is dried, after which it is ready for further use.

37. Selective Coloring Method

The selective coloring method is also suggested for contact preparation of duplicates of negatives on chrome-colloid emulsions, to reduce the consumption of silver and other expensive materials in short supply used in photographic work. It is based on the use of dyes, capable of coloring the unhardened colloid, and therefore makes it possible to obtain from a negative another negative (with mirror inversion), and a positive from a positive.

Several technological versions of the selective-coloring method were proposed, but all are of similar nature and consist of the following:

A plate coated with a copying emulsion is exposed under the negative (or positive), and is then placed in a solution of a dye, which colors only the unhardened colloid without coloring the hardened one. After dyeing the emulsion to the required optical density, the plate is washed and the copy is ready for work. In this case one obtains a negative from the negative, and a positive from the positive. Technologically, the process consists of the following operations:

- (1) preparation of the base;
- (2) coating the light-sensitive (copying) emulsion;

- (3) exposure;
- (4) dyeing;
- (5) washing and further treatment of copy and preparation for use.

Preparation of the base is the same as in the wash-off relief method. It is important that the base, regardless of its character, be thoroughly cleaned of all dirt. The NRKCh employs glass, viniproz, and other plastic materials as bases.

The procedure for coating of the light-sensitive (copying) emulsion is the same as in the wash-off relief method. In this method one employs different copying emulsions, part of which consists of chromated gelatine, and others, more complicated in composition, contain two colloids. By way of an example let us cite one of these formulas, which has given quite satisfactory results in practice. To make the working copying solution, two stock solutions are prepared:

First Stock Solution

Photographic gelatine	60 grams
Ammonium bichromate	20 grams
Water	1,000 ml

Second Stock Solution

Dry egg white	70 grams
Ammonium bichromate	20 grams
25% ammonia	approx. 20 ml
Water	1,000 ml

The working solution is made of a mixture of one part of the first and four parts of the second stock solution. Depending

on the time of the year and other conditions, a certain variation in the amount of gelatine is permissible (ranging from 70 to 120 grams/liter). The light-sensitivity of the ready solution is close to the light-sensitivity of the chrome-albumin emulsion.

The coated emulsion must be dried with observance of all the conditions indicated for the wash-off relief method. Experience has shown that if any plastic material is used as a base, it is necessary to dry it without heating, for these materials may warp even at a low temperature (40-45° C) and in many cases this may spoil the copy.

Exposure. In the preparation of duplicate negatives by the selective-coloring method it is necessary to employ longer exposures than in the wash-off relief method (by a factor of approximately 2 or 3). In the wash-off relief method the purpose of the exposure is to harden the colloid (gelatine) only to a state at which it can no longer be dissolved in warm water when the unhardened emulsion is removed. In the selective-coloring method it is necessary to attain a fuller hardening of the emulsion, for if the emulsion is not hardened enough the hardened emulsion may become partly colored, and consequently, fog may form.

The dried plate must be protected against light before and after the exposure, for even slight hardening of the emulsion may lead eventually to incomplete coloring and to a poor copy. This is particularly important because it is necessary, for technical reasons, to illuminate the emulsion slightly even without this.

After the plate is exposed under the negative, it is illuminated (10-15 seconds) on the reverse side (on the glass side). Such an additional exposure, although undesirable, is nevertheless essential to create conditions whereby the emulsion is fixed to the glass (or plate), otherwise the emulsion will not adhere strongly and may be washed off during the coloring process.

Coloring, as in the wash-off relief method, is carried out in a tray. A dye that is capable of coloring the unhardened colloid without affecting the hardened one is used.

The first dye suggested for the purpose (by N. I. Sinyakov) was Congo red. This is why the method is not called the "red negative method." It was later proposed (by D. A. Grigor'yev) to first color the negative in a solution of Congo red and then color it again in a solution of a green dye. The resultant background of the negative is dark and dense, differing little from the background of the negative made photographically. At present only a single black dye is used, thus yielding the same results as coloring with two dyes, but requiring a considerably simplified process. To insure the necessary optical density of the negative background for the copying of printing forms, the dyeing must be sufficiently intense.

The washing and all further operations in the preparation of the resultant negative and in its use are carried out the same way as in the wash-off relief method.

Practical work at the NRKCh has shown that the selective-coloring method is more cumbersome and less convenient than the wash-off relief method. The considerable increase in the exposure

sometimes causes the plate to stick to the negative that is being copied. This method requires a very accurate determination of the time of additional exposure, etc. This is why it seems more advisable to duplicate negatives by using the wash-off relief method via an intermediate positive.)

38. Mordant Coloring Method

A special version of silverless method of preparation of negatives (or positives) is a method occupying so to speak an intermediate place between the wash-off relief and the selective-coloring method. This method, so far not used widely in cartography, is called the mordant coloring method.

The essence of the mordant coloring method, developed by V. M. Perikov, consists in coloring not the colloid, but the base or a special emulsion coated on the base (if the base is glass). The technological process consists of ridding the exposed copy of the unhardened colloid (similar to the wash-off relief method), dyeing the mass of the base (or of the special emulsion coated on the glass) with special dyes, and then removing the hardened emulsion. As can be seen, the method makes it possible to obtain a negative from a negative and a positive from a positive, thus recalling the selective-coloring method.

The process consists of performing the following operations:

- (1) preparation of base;
- (2) coating the copying emulsion;
- (3) exposure;
- (4) development of the copied copy;
- (5) dyeing the copy;

- (6) removal of hardened emulsion;
- (7) washing and finishing the copy.

Preparation of Base. If plastic materials are used (cellulose film, viniproz, etc), the base is only cleaned of dirt. If the base is glass, as is more desirable, particularly for the publication of maps with very fine lines requiring accurate alignment of the elements, the preparation of the base becomes considerably more complicated. --

Since it is impossible to color the mass of the glass during the preparation of the negative, a special layer, suitable for coloring in the mass, is placed on it before the light-sensitive solution is coated. Such a layer may be celluloid, collodion, etc, but such a layer would not adhere strongly to the surface of the glass, and therefore it is necessary to introduce a substratum, which is capable of stronger adhesion to the glass and which contains in it the layer that is to be dyed. It is possible to use for this purpose albumin, gelatine, rubber, liquid glass, etc. The inventors of the method recommend a 1% solution of gelatine with chrome alum which is introduced in an amount of 1 gram per liter of solution. The substratum is applied with a pad on the previously-cleaned glass and is made very thin (up to 10 milliliter solution for a 50 x 60 cm plate), and is rapidly dried. The film that is to be colored is placed over the dried substratum and may consist of collodion (2% solution of nitro-cellulose or celluloid film in equal parts of alcohol and ether). The collodion is poured on as in the wet-collodion process, with the edges of the glass and of the substratum being covered with rubber before pouring. After drying, the plate is ready to be coated with the light-sensitive copying emulsion.

Coating the Copying Emulsion. Essentially the process does not differ at all from the analogous processes described above in the wash-off relief method and in the selective-coloring method. The difference lies only in the composition of the copying emulsion. By way of an example let us give several formulas.

1. First Stock Solution

Dextrin (potato)	400 grams
Ammonium bichromate	110 grams
Water	1000 milliliters

Second Stock Solution

Dry egg white	40 grams
Ammonium bichromate	12 grams
Water	100 milliliters

The working compound is obtained by mixing one part of the first solution with two parts of the second.

2. First Stock Solution

Photographic gelatine	80-100 grams
Ammonium bichromate	30 grams
Water	1000 milliliters

Second Stock Solution

Potato dextrin	400 grams
Ammonium bichromate	120 grams
Water	800 milliliters

The working solution is prepared by adding one tenth part (by volume) of the second solution to the first solution.

3. First Stock Solution

Resin of Siberian larch	3 parts
Ammonium bichromate (10% solution)	1 part

Second Stock Solution

Dry egg white	70 grams
Ammonium bichromate	20 grams
Water	1000 milliliters

The working solution is obtained by mixing equal parts of the two stock solutions.

The light sensitivity of the ready copying solutions is less than the light sensitivity of chromated albumin by approximately one and a half times.

From the formulas given above it can be seen that the copying emulsion contains two colloids, one of which coagulates vigorously and produces a stable film on the base, and the other adheres less to the base. The composition of the copying emulsion is chosen in this manner to produce stable hardened elements and to be able to remove the unhardened ones if not with water, then with soluble hygroscopic salts; at the same time, conditions are created for relatively easy removal of the hardened colloid.

The copying emulsion is coated on the prepared base in a centrifuge, observing all the conditions indicated above for analogous operations.

The exposure is carried out the same as in other methods. The exposure time is 1.5-2 times greater than the exposure time used in the chrome-albumin method.

Development of Copy. The above formulas for copying emulsions show that the unhardened parts cannot be removed from the plate with water, for this may also destroy the hardened elements. The unhardened colloid is therefore removed from the surface of the plate using a solution of hygroscopic salt, particularly calcium chloride. In analogy with other copying methods, this process is called development.

Development is in a 30-35% solution of calcium chloride (calculation based on dry salt), with the specific gravity of the solution being approximately 1.3. To develop the copy, the developer solution is poured on and is then spread evenly with a pad over the entire surface. The plate is rubbed (without excessive pressure) until all the unhardened colloid is removed from the surface. After development, the plate is immediately dyed without any intermediate operations.

Dyeing the Copy. As indicated above, the method of mordant coloring calls for dyeing in the mass the base or a special coating placed on the glass. For this purpose, so-called fat-soluble dyes are used which dissolve in substances in which celluloid and other bases can swell or may even dissolve (used in this method). These include alcohol, butyl acetate, acetone, etc. Certain of the formulas of the coloring solution are given below.

1. Fat-soluble Indulin	30 grams
Brown or orange fat-soluble dye	15 grams
Rectified alcohol	500 milliliters
Butyl acetate	75 milliliters

2. Fat-soluble Indulin	1 gram
Brown fat-soluble dye	6 grams
Acetone	1000 milliliters

Coloring is done by rubbing the copy with a cotton pad, moistened with the dye solution, until the emulsion has the proper saturation.

Removal of the hardened emulsion and washing of the copy are usually carried out simultaneously. When the copy is rubbed with a cotton or gauze pad under the stream of water, the hardened emulsion is removed as the copy is washed. To facilitate the removal of the hardened emulsion, the colored copy is rubbed with a pad moistened with a 2-3% solution of caustic alkali, after which it is thoroughly washed. Finally, the surface of the copy is covered with a protective lacquer to create conditions for uniform application of the ink when the negative is retouched.

CHAPTER 13

WORK PERFORMED ON OFFSET PROOF PRESSES

Work performed on offset proof presses occupies a substantial place in the entire process of map publication. The proof presses are used to print line and color proofs of the maps, to prepare "phantom outlines" for the preparation of background printed forms, machine printed forms, and other operations of auxiliary nature (printing various proof copies etc). The proof press work is used to treat both the original printing form as well as the products that result from the form. This is why technically-correct and rational performance of these operations may be of decisive

importance in the entire course of the publication of maps or an atlas.

The principal processes performed on the offset proof presses are;

- (1) printing the color (or line) proof;
- (2) preparation of "phantom outlines" for the manufacture of background printed forms;
- (3) preparation of machine printing forms.

39. Regulation of the Offset Proof Press

Correct and high-grade performance of any of the above operations calls for an accurately adjusted offset proof press. The process of printing with an offset proof press consists, as is known, of transferring and printing a drawing, placed on the original printing form which is attached to one bed to another surface, attached to the second bed, with the aid of a rubber apron, stretched over a special cylinder.

When working with the press, it is necessary to insure that the dimensions on the print are exactly the same as those of the image on the initial printing form, and that all details of the drawing are correctly transferred without distortion (without becoming thicker, without shifting, or without similar defects). This can be obtained by accurately adjusting the mutual relationship between the first (form) and second (printing) beds and the cylinder of the offset proof press.

Regulation of Position of the Beds and of the Cylinder of the Offset Proof Press.

The most typical and most frequently encountered shortcomings are as follows:

- (a) the beds are not on the same plane, but are parallel to each other;
- (b) one bed is tilted;
- (c) both beds are tilted;
- (d) the axis of rotation of the cylinder is not parallel to the plane of the beds.

In practice it turns out most frequently that when the proof press does not operate correctly there are several errors acting at once, and this makes it impossible to determine immediately the actual cause of the incorrect operation of the press and to eliminate this cause. Therefore, if the press is to be properly adjusted, it is necessary to check it thoroughly as soon as it is noticed that it is not operating correctly.

The beds of the offset press must be in the same plane, in a strictly horizontal position. When the cylinder passes over the beds with the press turned on, the gap between the rings of the latter and the guides (on the sidewalls of the press) should be 0.3-0.4 mm. The gap is best tested with a feeler gauge, and the correct relative position of the beds is best checked with a control-measurement rule, proposed by A. A. Petrovich, a worker at the NRECh.

The control-measurement rule (Figure 63) is a simple instrument, insuring, however, high accuracy of setting of the beds of the offset press and their regulation. Mounted on a rectangular steel rule 1 are two indicators 2 and two supports 3, which are mounted

in movable sleeves. The indicators can move in a vertical direction, this being important for their initial setting and when checking the press. The indicators are attached on opposite ends of the rule at a distance smaller than the width of the bed. The mountings are so installed as to fit them on the guides of the press.

When checking the setting of a bed, the rule is placed on the bed (on the diagonal) and the indicators are moved vertically to set them in such a position that the pointers indicate half the measurement range (for example, the measurement range of the indicator is 2 mm, they are set so that the pointer on each of the indicators shows 1 mm). After setting the indicators in the initial position, the correct position of the beds is checked. By placing the rule with mountings 3 on the guides of the press, the readings of the indicator are checked on one side of the bed, and then the rule is moved to check the other side. If the bed is correctly installed, the indicators should give the same readings for all four points. Any tilt will be noticed by the indicators. The positions of the beds are corrected by means of hand wheels (in the case of the printing bed) or by adjusting screws (form bed). By checking the position of both beds of the offset proof press by means of the control-measurement rule, it is possible to determine whether the beds are in the same place, whether there is any tilt in the position of any one or both beds.

Using a feeler gauge to check the gap between the rings of the cylinder and the guides of the press, it is possible to establish not only whether the gap is of the right size, but whether there is

any tilt in the mounting of the cylinder, i.e., to check whether the axis of rotation of the cylinder is parallel to the plane of the beds of the press.

In view of the fact that the guides of the press play such an important role, being the only means by which it is possible to establish whether the press is suitable for work, they must be maintained with particular care. They cannot be polished, filed, etc; they cannot be allowed to corrode in any manner, and therefore they must always be accurately lubricated. The press should be checked either by the press printing operator, the foreman of the section (shift), or a mechanic, but the adjustment must be entrusted only to the mechanic.

In practice one encounters sometimes cases when many adjustments of the press do not lead to the desired results. This may be due to the poor condition of the shock absorbers. This fault cannot be eliminated by any adjustment whatever. It can be eliminated only by replacing the shock absorbers, i.e., by repairing the press.

One can proceed to print only after carefully checking the press.

40. Printing the Color (or Line) Proof

The complexity of the work consists of the fact that it contains many colors. When printing the proof the press operator should produce the overall tone of the map in accordance with the colored original, with high polygraphic quality, and with as accurate a combination of colors as possible.

If the original is made to correspond to previously known combinations of printing colors (for example, in accordance with the color chart), or if proofs of color combinations were run prior to the final schedule of the tone combination, the reproduction of the original becomes considerably easier. This problem is resolved relatively easy, if the job is a regular-production item (for example, topographic maps) or if the job has been well mastered. If the job is performed for the first time and no preliminary combination of colors was printed, the press operator together with the technical editor must establish the shade of each color during the printing process, taking into account the possible mutual relationships between colors. This is a complicated creative process and there are no ready made formulas for all cases. The general rule is that the shades of the color must be selected in accordance with the full tone, i.e., in accordance with the solid color, bearing in mind that any error made in the solid tone is reduced by 30, 50, and 70% after screening, but if the color is chosen in accordance with the screened appearance, the error in the solid color may increase by one third, or by two or three times.

When printing with modern offset inks, which are all lacquers and therefore transparent, the sequence of printing should be established only on the basis of the convenience in work. If regular-production jobs are printed, the sequence with which the inks are applied is of no consequence as far as the overall tone of the map goes. If the proof, however, is printed for the first time and there are no analogous jobs against which to establish accurately the ink shades, it is necessary to print first those inks,

variations in the shades of which do not affect substantially the overall tone of the map; to the contrary, those inks that establish the general coloring of the maps (particularly in combination with other inks), must be printed last. This rule should be adhered to in all cases, and in the case of continuous production, when the printing begins even before all the printing forms have been produced, the sequence in the preparation of the forms should also follow this rule.

After each color is printed, a certain time should elapse before one can print the next color. This time may vary. The opinion held by many specialists that only one color can be printed in one day is not at all founded. Experience has shown that in many cases it is possible to print two and sometimes three colors in one day without damaging the quality of the proof. However, certain rules must be obeyed here.

The deterioration of the quality-results from printing several colors in one day may be due to two causes: (1) formation of an excessively thick layer of talcum after powdering the fresh print and (2) squeezing of the already printed color from the paper onto the rubber when the next color is printed. Experience at the NRECh has shown that after 3-4 hours the ink on the print is dried to such an extent, that if it is dusted with talcum powder only a very thin layer of powder remains on it. This is in good agreement with theoretical calculations on the drying of thin films of drying oil. However, if the print is left for even two days, it will still be necessary to dust it with talcum to print the next color. Whether the print dries for four hours, or whether it dries for 30-40 hours, the thickness of the talcum-powder layer

will be practically the same. Consequently, if one color is printed at the beginning of the shift, and the other at the end, there will be no deterioration of the quality of the proof. An exception may be the case of certain particularly fine line elements, such as outlines and lettering in summary atlases, which should be printed one a day. In this case the lettering, for example, can be printed not with the first but with the second color, but towards the end of the shift, so that the color has a chance to dry overnight.

When printing a color proof of a multicolor map, the printing of several colors per day is also dictated by the consideration that if the printing time is prolonged, the deformation of the paper, occurring as the result of variation in temperature and humidity, deteriorates considerably the quality of the proof as a rule.

The sequence in which the colors are printed is immaterial. Nevertheless, it is better to start printing the proof with the line elements, including the lettering, and then to print the background colors. The desirability of printing the lettering before printing the background colors is explained by the fact that the letters are printed better on clean paper than on a layer of ink. This is of particular significance for summary maps (atlases) containing much lettering, where thin and small lettering is used.

The quality of the color proof is affected by the quality of the printing forms. It is necessary to bear in mind that in this work a poor printing form does not yield a good print, and it is therefore better to make a new printing form (even if it requires considerable time), rejecting the poor one prior to the proof.

Lack of color registration in printing may be caused by many factors, the principal of which are: incorrect operation of the press, great differences in the thickness of the aluminum plates on which the printing forms were prepared for the different elements, inaccurate work of the printing press operator himself, and deformation of the paper.

Factors causing incorrect operation of the press were considered above, and as already indicated, a color proof cannot be printed on a press that is out of order.

The effect of the thickness of the aluminum plates on which the printing forms are prepared is not great. However, along with other causes, this also may lead to unsatisfactory printing results. By way of a precaution, the plates used for the printing forms required for the same sheet of the map should be as nearly equal in thickness as possible, with deviations not more than ± 0.05 mm.

During the process of printing the proof, the press operator places manually each sheet of the paper on the printing bed. It is necessary that he do it in exactly the same manner, for the position of the sheet on the bed, and consequently the registry of the color in printing, depends on how rapidly and energetically the printer brings the sheet to the lateral and forward stops of the press. Naturally, the placement of the form should also be with sufficient accuracy. Inaccurate feeding of the sheets to the forward and lateral stops is in many cases the principal cause of poor registry of colors on the color proof, if the forms have been made with "phantom outlines" with accurate dimensions, and if the adjustment of the forms has been made carefully.

Finally, another reason for incorrect registry of the colors is the deformation of the paper resulting from a change in the humidity and temperature of the room in which the printing takes place. To prevent deformation of the paper or to reduce its effect, it is necessary to print only from a dry form. Unlike printing with rotary machines, this condition is fully attainable in an offset press. For this purpose it is necessary to dry the form after the ink is rolled on, and the print should be made only afterwards.

In addition, it is advisable to pass a paper once or twice under the press of the cylinder of the offset proof press before printing, thereby reducing considerably the deformation occurring during the printing of the proof. It is probable that passing the paper under pressure removes from it to a considerable extent the residual internal stresses and such a relaxation contributes to a more stable behavior of the paper when printed.

As can be seen, the accuracy of the registry of the colors is influenced by many factors, which cannot always be taken into account and allowed for beforehand, although this is very important. Good results were obtained at the KRECH, when printing color proofs of the World Atlas, by starting the printing of the color proof with the outline in which all the colors were registered in sequence. Such a procedure cannot be used for all maps, but only for complicated ones. The extra time lost is fully compensated for in subsequent work, which proceeds rapidly and reliably.

The sequence of operations is of great importance when printing color proofs of multi-sheet maps or printing sheets of individual maps for an atlas. In addition to the general technical rules, it is necessary to take into account also the specific features and the peculiarities of this work.

The printing of a color proof of a multi-sheet map is made more complicated by the fact that it is necessary to maintain the same shade in all the elements that are placed in various sheets of the map. This requirement, which must be fulfilled in the case of all multi-sheet maps, can be satisfied if the screens used for identical elements located on different sheets of the map are copied from the same negative and at the same time, and if the same elements are printed on the different sheets of the map with ink that was mixed at the same time. It follows from the latter requirements that the color proof of a multi-sheet map is best printed in sequence, the same way as a run is printed on the offset machine. In other words, one cannot proceed to print the next element until the preceding element is printed on all the sheets of the map.

Better results are obtained when printing with stock inks rather than with mixed inks. However, this is not always possible. In particular, in various general-geographic and special wall maps it is necessary in most cases to print the background elements with mixed inks. For the most accurate color reproduction in the printing of a run on offset machines it is necessary to fix rigidly the composition of each ink used to print the proof.

The problem is solved in a different manner if the background portion of the map is produced in accordance with the **TaNIIGAik**

technology, proposed by S. F. Sadchikov, in which the entire color range of the map (with the exclusion of the line elements) is reproduced with three or four colors. Without going into details concerning this problem, let us merely indicate that the TsNIIGAIK technology calls for working principally with standard factory stock colors (at least three colors). The work involved in preparing the color proof becomes less complex when it comes to selecting the required printing shades, but the preparation of the printing forms, in particular, accurate reproduction of the required screens, becomes more complicated.

None of these considerations pertains to printing regular-production multi-sheet maps (for example, topographic ones), which should be printed only with integral, specially-prepared standard colors. It is also advantageous to employ standard factory colors for the publication of maps or atlases, which are printed at various enterprises in large runs and particularly for the publication of large and complicated editions (for example, the World Atlas).

41. Preparation of "Phantom Outlines" for Background Printing Forms

The background printing forms are prepared in most cases by a combination of engraving and photo-copying operations. The engraving operations consist of opening up on the form the places corresponding to the solid tone, and outline the places, corresponding to the various shades of this tone ("screens"). In case of photo-copying work, the screens are copied into these places.

The following requirements must be satisfied by the "phantom outline."

(a) The drawing should be clear and readily legible; so that the engraver can determine without error during the operating process the contours that serve as boundaries for the tone that they separate.

(b) The dimensions of the "phantom outline" should correspond to the dimensions of the remaining printing forms (in this case the line forms).

(c) The drawing must not take the ink even upon prolonged storage of the printing form.

(d) The drawing should be properly placed on the plate.

The first three conditions are best satisfied by "phantom outlines" obtained by photomechanical means as a result of copying with iron salts. However, under certain conditions "phantom outlines" prepared on an offset press may also fully satisfy the above requirements.

Since the process of the direct production of the "phantom" outline image on the aluminum (or zinc) plate is a printing process, and since the quality of the print depends first of all on the quality of printing form, the outline form, from which it is necessary to prepare the "phantom outlines," must meet high standards. This pertains first of all to the quality of the drawing. The drawing on the outline should be sharp, without excess lines, dots, etc, fully corresponding to the publishing original, i.e., its contents should be an exact copy. It is desirable to copy the outline form from a negative that has not been retouched, for in this case it is easier to obtain on the outline form a thin

and very sharp drawing. However, in the presence of faults in the negative (dots, scratches, or other transparent spots) it is best to retouch the negative prior to copying the outline form, so as to free the outline form from unnecessary elements, which the engraver may erroneously assume during his operation to be outlines. Thus, a sharp image can be insured on the "phantom outline" if a good outline printing form is produced.

Before printing on the aluminum, a print is made on paper, and if this print is thoroughly examined and found satisfactory, the printing is performed on the aluminum.

"Phantom outlines" can be printed in any color, but in most cases they are printed blue. For this purpose, one usually employs blue offset ink No 311, as being most easily washed off and degreased, leaving a noticeable trace on the aluminum which makes it possible to control visually the quality of the printing form. Since ink No 311, as any other offset ink, is greasy, it should be removed from the surface of the "phantom outline." However, if it is removed from the form immediately after the print is made, no clear trace will remain on the form, and it is therefore necessary to leave the future "phantom outline" on the plate for some time after the print was made. This time must not be long to prevent the ink from strongly greasing the surface of the form and creating stable printing elements, otherwise the "phantom outline" will be unsuitable. Experience has shown that this time must not exceed 30-50 minutes.

The treatment of the "phantom outline" consists of removing the ink and hydrophilization of the surface of the form. The ink

is washed off with benzine in the usual manner, using a cotton pad. After the ink is removed, there remains a weak but clearly visible trace at the places where it was coated. If the form is left in this state, the faint printing forms may become subsequently reinforced and gradually produce a print; this is not permissible. To prevent this, the "phantom outline" is treated with a strongly-hydrophilizing solution, which hydrophilizes not only the blank spaces but also destroys the printing elements produced by the ink, which should also become hydrophilic. Although it destroys the oleophilic film produced on the plate in the location of drawing, the hydrophilizing (etching) solution does not remove the pigment in the ink, which remains on the form and produces the "phantom" outline drawing.

The surface of the plate is treated with the hydrophilizing solution for 1-3 minutes, using a gauze pad. The hydrophilizing solution is then covered with a pad, the plate is washed once again in water, and is dried.

The surface of the "phantom outline" is then covered with a thin layer of starch solution, using a gauze pad. Such a "phantom outline" is ready for further work.

The drawing should be correctly placed on the "phantom outline." It is essential above all that the so-called "gripper line" be correctly placed on the form, along one of the long sides of the sheet, on the side where the most accurate registration of the drawing is required. On a four-sheet map, for example, these are most frequently the southern sides of the first and second sheets and the northern sides of the third and fourth sheet for maps that

are longer in the direction of the parallels; for maps longer in the direction of the meridians, these are the eastern frames of the first and third and western frames of the second and fourth sheets.

The gripper line must be measured as accurately as possible, for the device available on the proof press for fitting the form does not provide for much motion. The location of the gripper line and various printing forms for a single sheet of the map should not deviate (from the edge of the plate) by more than 4-6 mm, otherwise the plate must be cut when fitting, thereby spoiling it and involving additional loss of time. The drawing on the "phantom outline" must be placed along the gripper line symmetrically with respect to the edges of the plate.

When the "phantom outline" is prepared on the proof press it is not always possible to obtain exact dimensions and it becomes necessary to establish the maximum permissible tolerances that would not lead to noticeable out-of-register of the ink in printing. It is necessary to take into account here that differences in the dimensions manifest themselves differently in different elements of the map. Out-of-register is least noticeable if the color changes gradually, when one color appears as an underlining for the other, for example, the hypsometric coloration on classroom wall maps. Out-of-register is most noticeable at the contact lines between different colors, if one color is not an underlining for the other. For example, the boundary between the color for dry land and for the sea on classroom wall physical maps or the circles corresponding to populated areas and railroad lines, if the former are printed together with the hydrography in

blue colors, and the latter in red, etc. Thus, to determine whether dimensions are within or outside the tolerance on a "phantom outline," it is necessary to take into account how much these distortions will affect the registry of the elements on the map when printed. For the sake of illustration, let us consider the effect of the error in dimensions on the register on the green and blue colors on a classroom wall physical map.

The shoreline, which is the boundary and at the same time the joint between these colors, is drawn on the wall maps at a thickness not less than 0.5-0.6 mm. If the inking in the engraving operations is carried out to the middle of the boundary line, the difference in linear dimensions of the image, not exceeding 0.2-0.3 mm, will not affect noticeably the registry of the ink in printing. If we take into account that during printing (of the color proof on the proof press or the run on the production machine) the deviation from ink registry may become distributed to both sides of the center of the line, one can assume that errors in the dimensions of the image on the "phantom outline," not exceeding two thirds of the thickness of the line used to separate the colors, can be considered as the permissible limit. Denoting the thickness of the line by l and the tolerance by Δ , the above can be expressed in the form of an equation

$$\Delta = \frac{2l}{3}.$$

For classroom wall maps, where l is 0.5-0.6 mm, the permissible fluctuations may be as high as 0.3-0.4 mm, and this is confirmed in practice. On summary maps, in which $l = 0.3-0.4$ mm, the tolerance may be 0.2-0.3 mm.

Having established the maximum permissible differences between dimensions on the image on the different printing forms, it is necessary to be cautious that deviations in dimensions from those specified be of different signs on different forms. If this is not taken into account, the work may be spoiled by poor registry of ink in printing. Let us assume that the dimensions of the "phantom outline" of the blue ink (color for the relief of the sea bottom) is less than the dimensions of the image on the form of the hydrography by 0.3 mm, and the dimensions of the "phantom outline" for the green ink (first step in the hypsometric color) is greater than the dimensions of the hydrography also by 0.3 mm. While the two deviations from the specified dimensions on each form are in themselves within the tolerance, it is impossible to obtain good registry, for the errors in the dimensions will add up and the discrepancy between the dimensions of the image on the printing forms for the blue and green ink will be not 0.3 but 0.6 mm, which exceeds the permissible deviation. Considering that the paper deforms during printing and increases in size in most cases, one can consider it a rule that the dimensions of the "phantom outlines" for the preparation of the background colors should never be less than the dimensions of the line elements, which are the boundaries of these colors.

42. Preparation of Machine Forms

The preparation of machine printing forms on the offset proof press is called in the trade "transfer." The method consists essentially of transferring the image from the original printing form to an aluminum (or zinc) plate, which after suitable treatment becomes the printing form for printing the run.

Inasmuch as the general theoretical (fundamentals of the process) and practical (concerning the dimensions of the image etc) problems have been considered above, we shall dwell here only on certain features peculiar to machine printing form.

In addition to the general requirements concerning the printing form, the machine printing form, produced by the transfer method, must satisfy the following special requirements:

- (1) The quality of the image must not differ noticeably from the image contained on the original printing form.
- (2) The dimensions must not deviate from the calculated limits.
- (3) The drawing must be correctly placed on the plate.
- (4) The form should give a clean and sharp print.

When these conditions are satisfied, the machine printing form is considered to be of high grade.

The quality of the image on the printing form depends fully on the quality of the original printing form. The latter must therefore satisfy the highest requirements. However, by virtue of many factors the original form frequently has substantial shortcomings (for example, owing to the large number of corrections). In these cases the machine form must be prepared by transfer with particular care.

Difficulties are caused in most cases by the blank elements. An original form, subjected to considerable corrections, contains as a rule many traces of cleanings which may produce a faint print

because of the damage to the surface ("shadowing"). To avoid this, it is necessary to hydrophilize such places additionally. It is also possible to remove the "shadows" from the rubber apron before reprinting the image on the plate. Finally, they can be removed from the transfer itself with benzine. In this case it is necessary to grain such places manually so as to destroy the form printing elements without destroying the structure of the surface of the plate.

The dimensions of the image on machine printing forms (transfers), particularly for line elements, should be accurate, but in practice it is almost impossible to obtain a transfer with exact image dimensions. Therefore the permissible tolerances in the dimensions are so established that they do not spoil the overall view of the map as seen by the eye.

The dimensions of the sides of the cartographic drawing are checked on the form with an ordinary rule and at least two measurements must be made. Taking into account that the accuracy of the reading is within 0.1 mm, the error in the dimensions of the sides will be $0.1\sqrt{2}$ mm, i.e., approximately ± 0.15 mm. Thus, deviations in dimensions between two different forms may reach $\pm 0.15\sqrt{2}$ mm, or on the order of 0.2-0.3 mm.

As in the preparation of "phantom outlines," it is necessary to see to it that deviations in the dimensions of sides at different transfers for the same sheet of map be of the same sign. The correctness of the dimensions must be checked with six measurements (i.e., measuring the four sides and two diagonals of the image) with an ordinary rule.

The remaining elements making up the technological process of manufacturing the machine printing form on an offset proof press have been considered in other places in connection with other problems and will not be repeated here.

Part III

TECHNICAL EDITING OF MAPS AND ATLASES

CHAPTER 14

ELEMENTARY INFORMATION ON COLOR PRINTING

43. Colors of Bodies

The end purpose of all the map-publishing processes is to obtain a finished print of the map, the quality of which depends to a great extent on its coloring. Persons engaged in the publication of maps must therefore have an idea of at least the fundamentals under which the human eye perceives different colors and their combinations.

The colors in the spectrum are arranged in a definite sequence, depending on the wavelength of the various rays, from the red, which corresponds to the longest rays (760 millimicrons) to the violet, corresponding to the rays with the shortest wavelength (400 millimicrons). All the colors in the spectrum can be reduced to several groups of colors, which differ noticeably from each other, each group comprising rays with a definite wavelength. An idea of this can be gained from Table 16, in which the colors are given in the same order as their location in the spectrum.

TABLE 16

COLORS OF THE SPECTRUM AND CORRESPONDING WAVELENGTH

Wavelength of light in millimicrons	Color sensation occurring when they act on the eye
760-620	Red
620-590	Orange
590-560	Yellow
560-530	Yellow-green
530-500	Green
500-470	Azure
470-430	Blue
430-400	Violet

The spectrum represents, so to speak, the white color that has been broken up into its component parts, since the white color consists indeed of a mixture of all the spectral colors. This was proven already by Newton, who was the first not only to analyze artificially the white color and produce a spectrum, but to construct a color circle, containing the colors of the spectrum, which when rotated rapidly would be seen by the eye as white.

Consequently, if all the rays with wavelengths from 400 to 760 millimicrons are made to act on the human eye in some definite proportion, the sensation of white color will be perceived. If, however, rays with a limited wavelength act on the eye, the sensation of some definite color other than white will be produced. It follows from the above that the color of any body, surface, etc, depends on what rays are radiated or reflected by this body.

Color may strike the human eye either from bodies which radiate it, i.e., which are themselves sources of light, or from bodies that

do not radiate but reflect light radiated by other bodies and incident on their surfaces. The moon, for example, does not radiate light itself, and we see it only because it reflects from its surface the incident light from the sun.

Some bodies transmit light and are called transparent, others do not transmit light and are called opaque. Not all the light passing through a transparent body emerges from it, but part of it is absorbed by the body. Various bodies have different properties of transmission and absorption of rays of light (It must be taken into account that no body is absolutely transparent, nor is any body absolutely opaque). Some transparent bodies transmit all the rays of the spectrum in an equal amount. Such bodies are said to have the property of non-selective absorption. Other bodies transmit only some light rays of a fixed wavelength, and absorb the remainder. Such bodies have the property of selective absorption. Uncolored glass has the property of non-selective absorption, but glass of any color (red, green, yellow, blue, etc) exhibits selective absorption.

If the glass has the property of selective absorption, for example, in the portion of the spectrum from 400 to 590 millimicrons, it will appear red in transmitted light, for it will transmit only rays with wavelengths from 590 to 760 millimicrons, i.e., the red-orange portion of the spectrum. It will appear blue in transmitted light, for it passes only the short-wave portion of the spectrum, i.e., rays with a wavelength from 500 to 400 millimicrons, corresponding to the azure, blue, and violet rays.

If two pieces of glass, one colored blue and the other red

are superimposed and looked through, they will appear black or almost black. This is caused by the fact that the red glass absorbs rays with a wavelength from 590 to 400 millimicrons and passes 590-760 millimicron rays, but this part of the spectrum is absorbed by the blue glass and thus, two pieces of red and blue glass superimposed on each other absorb all the rays of the spectrum (Figure 64).

Opaque bodies, like transparent ones, have either the property of non-selective absorption and then appear white, gray, or black, or else the property of selective absorption and then seem to have some color.

Any opaque body if cut in a very thin layer transmits rays, i.e., is transparent to a certain extent. Let us assume that a body having selective absorption, for example in the blue-green portion of the spectrum, is exposed to white (for example sunlight) rays. Some of the rays will be reflected from the surface of the body and naturally will not change their composition (or their color). The remaining rays will be absorbed by the body. Passing through the upper layer of the particles of the substance of the body, these rays will experience selective absorption. Not all their rays will strike the next layer of particles but only those which have passed through the first layer, i.e., the rays of the yellow-red portion of the spectrum. Upon reflection from the second layer of the particles of the body the rays will again pass through the first layer and strike the eye, causing a sensation of red, orange, or yellow color, which will be perceived as the color of the body (Figure 65).

The processes occurring in nature are naturally considerably more complicated than those described here. One can understand,

however, from the schematic description of the process, why the colors of opaque bodies are determined by their selective-absorption properties.

The very rich assortment of color hues observed in nature consists of two groups of colors. There are colors that differ from each other only in brightness, i.e., only quantitatively (white, gray, black). Other colors differ from each other not only in brightness but also in the hue, i.e., not only quantitatively but also qualitatively. These colors include all the colors in the spectrum, namely violet, blue, azure, green, yellow-green, yellow, orange, and red. The first group of colors is called achromatic, the second chromatic.

The chromatic colors differ from each other in plainly visible qualitative features (red, yellow, etc). The achromatic colors are subdivided into black, dark gray, middle gray, light gray, and white. Such a subdivision is naturally arbitrary, for there are no distinct boundaries separating one group of colors from another (for example, light gray from medium gray or medium gray from dark gray), as in the group of chromatic colors.

If all the colors of the spectrum are arranged in a circle and if we also include purple, which is lacking from the spectrum and which is intermediate between violet and red, then by dividing the circle in two so that one half contains the red, orange, and yellow colors, and the second half the green, blue, and azure, it is possible to obtain two groups of chromatic colors, the former being called the warm group of colors and the latter the cold group.

Achromatic colors can be differentiated from each other merely by their brightness, but such a distinction is not enough for chromatic colors. Nor is a distinction by hue alone enough. Let us attempt, for example, to add to green or to red paint a gray paint of equal brightness; we then obtain different shades of these inks (blue or red) of the same hue and of the same brightness, but still different from each other. These differences will lie in the saturation of the color.

Thus, achromatic colors differ from each other in brightness, and chromatic colors differ in brightness, hue, and saturation.

Any hue, with the exception of purple, can be matched against an equal one in the spectrum with corresponding wavelength. Consequently, any hue, with the exception of purple, can be characterized by its wavelength.

A map must be used under various illumination conditions. It is therefore important for the map publishers to know the laws of variation of the colors of bodies (surfaces) with the spectral composition of the illumination.

The color of a body depends on its selective-absorption properties. This means that it depends on the spectral composition of the illumination. Let us imagine that we have illuminated a certain body, having a selective absorption in the blue-green portion of the spectrum, with blue light. Since the rays incident on the body are absorbed by the body and are not reflected from its surface this body will appear black. If a geographic map is printed in the colors that are conventionally used in map publishing and illuminated with red or orange-red light, the

hydrographic network, for example, which is printed blue, will appear black or nearly black; inscriptions printed black and which are well legible in the places where they intersect the lines of the hydrographic network in daylight, may be difficult to read in red illumination or may even be entirely illegible; the blue color of the sea will appear gray, etc. When choosing ink for map publishing it is therefore necessary to take into account the possible variation in their color, depending on the spectral composition of the light under which these maps will be used.

Changing the spectral composition of the illumination of the body changes in general not only the hue but also the brightness. In the case of electric illumination, for example, the red, orange, and yellow colors become brighter compared with sunlight, and the azure, blue, and violet colors become darker; the orange colors become somewhat more red; the bright yellow colors become almost indistinguishable from white; the azure colors become somewhat green; the dark blue colors become difficult to distinguish from black. Violet becomes somewhat more red and approaches purple.

44. Color Mixing and Ink Mixing

Modern theory of color vision is based on the fact that the human eye is provided with color analyzers, each of which is sensitive to a definite color. This theory, the founder of which is the great Russian scientist M. V. Lomonosov, is called the three-component theory of color vision. It is evident that the color analyzers of the human eye should be sensitive to such colors, the mixing of which makes it possible to obtain any shade of any color observed in nature. Many investigations have established that such colors are the red (with a wavelength of 630 millimicrons),

green (approximately 350 millimicrons) and blue (approximately 450 millimicrons). These colors are customarily called the fundamental colors.

If these colors are placed at the peaks of an equilateral triangle in amounts needed to obtain white color upon mixing, we obtain the so-called color-mixing triangle (Figure 66). As can be seen, this triangle represents a folded spectrum, to which the purple color is added. On the red-green line are placed the red, orange, yellow, and yellow-green colors; on the green-blue line are placed the green, azure-green, azure to blue colors, and on the blue-yellow line are placed the blue, violet, purple, and dark red colors.

If an equilateral triangle is inscribed in the color circle in such a way that its vertices touch the red, green, and blue colors with the wavelengths indicated above, we obtain the same color-mixing triangle (Figure 67).

Colors lying on the opposite ends of the diameter of the circle are called complementary. Complementary colors have a very important property: when optically mixed with each other they produce an achromatic (gray) color. Such complementary colors are, for example, yellow and blue, orange and azure, red and green, etc. (One must not confuse the above color mixing with the mixing of inks, which is subject to somewhat different laws, which will be discussed below).

Any time other non-complimentary colors are mixed optically, the result is always a new color, which occupies on the circle an

intermediate place between the two mixed ones. Thus, mixing blue and red produces violet, yellow and red produce orange, yellow and azure produce green, etc.

The three-component theory of color vision assumes that the perception of chromatic color depends on what analyzers of the color vision have been subjected to the action of the light energy and with what intensity the light reacted on them. If all three analyzers respond in suitable proportion, i.e., red, green, and blue, a sensation of white or gray color is received. but if two analyzers respond, the sensation is that of a mixed chromatic color, depending on which of the analyzers were actually subjected to the action of the light energy. Finally, if only one of the color analyzers responds, we obtain the sensation of one of the basic colors -- red, green, or blue. It must be borne in mind that the sensation of white (or gray) color occurs only in that case when all three analyzers respond with a definite intensity, i.e., when they are stimulated by the light energy in a definite proportion. Any disturbance of this ratio causes the eye to begin sensing not an achromatic color but a chromatic color. The optical mixing of the colors is called additive, for the changing color occurring during the mixing of the color rays is due to the fact that one hue is added to the other hue. This finds extensive application in decorative planning where any one object is illuminated by beams of light of different chromatic colors, in other branches of art, and in engineering.

In map publishing, the optical mixing of colors may be of importance in those cases when fine screens and grids are used in printing and are printed in different colors. The chromatic rays,

arriving into the eye from the individual elements, are mixed and upon entering the eye excite the color analyzers in a suitable manner and cause the corresponding reaction. Therefore, if two fine screens, for example, are printed on the map, for example azure and green, the eye will perceive this place to be colored green, a yellow and red screen produce an orange color, etc.

In map publishing inks are frequently mixed and superimposed one on the other to obtain the necessary tones. To control these processes properly and to use them intelligently for the improvement of the quality of maps, it is necessary to have at least some knowledge of the laws applying to these processes.

Persons working in map publishing know from practical experience that mixing two or several inks of different colors results in a new ink, not similar in color to any of the mixed ones. Thus, for example, if yellow and blue inks are mixed in a definite proportion a green ink is obtained. Mixing yellow and red inks can produce orange. Blue and red mix into violet, and etc. What are the laws applicable here?

There is a principal difference between the mixing of light (colored) rays and the mixing of inks. In the case of rays we have additive mixing, but things are different in the mixing of inks.

Let us imagine we mixed two inks: blue and yellow. As in the case of additive color mixing, the result is a green ink and on first glance it may appear that the same processes occur here as in the mixing of yellow and azure rays. Actually, things are entirely different.

The green ink obtained by mixing yellow and azure is a mass in which very fine yellow and azure particles are thoroughly mixed together. Why does the eye perceive it as green?

The yellow ink represents a mass of minute pigment particles having the property of selective absorption of all rays with the exception of yellow and yellow-green. The azure ink also represents a mass, the particles of which have the property of selective absorption, but for other rays -- all with the exception of azure and green-azure.

When the two inks are thoroughly mixed, the particles of their pigments are arranged alternately. What happens when rays of white light strike such a mixture? A ray of white light, striking, for example, a yellow particle and passing through it encounters a azure particle and is partly reflected from it, and partly passes through it further. But both the ray reflected from the azure particle and the ray passing through it will no longer be white. Having experienced selective absorption in the yellow particles, it emerges with a wavelength corresponding to the yellow color. This ray will be partly absorbed by the azure particle and partly reflected. The same transformation will occur with a white ray first striking the azure particle and then the yellow one, the only difference being that the azure ray will be reflected. Thus, after multiple absorption and reflection, the white light striking the mixture of yellow and azure ink loses all rays with the exception of the azure, yellow, and green, which, upon entering the eye, cause a sensation of green color. This can be explained graphically by the following scheme (Figure 68).

By varying the proportion of yellow and azure inks it is possible to obtain a darker color, i.e., one closer to azure, or a brighter color, i.e., one closer to yellow green.

Such a mixing of colors is even easier to visualize if one superimposes, for example, two pieces of glass, one colored azure and the other one colored yellow. Looking through such a double glass, we see a green color.

The yellow glass has selective absorption for all portions of the spectrum except yellow, and partially also for the yellow portion of the spectrum (500 -- 590 millimicrons). The glass will pass these rays. A glass colored azure has selective absorption for all portions of the spectrum with the exception of azure, blue, and some yellow rays (430 -- 530 millimicrons), which it transmits.

Let us now assume that an azure glass is placed in the path of white rays. It will absorb all the rays with the exception of rays with wavelengths ranging from 430 to 540 millimicrons. But these rays, having passed through the azure glass, will encounter farther on along their path a yellow glass which absorbs the rays with a wavelength shorter than 500 millimicrons and will pass only rays with a wavelength of 500 -- 530 millimicrons. These indeed are green rays.

We see thus that what we have here is not addition of colors, but to the contrary, subtraction. This method is therefore called subtractive.

The clearest example of color subtraction is the example given above with superposition of two glasses, one blue, and the other red. Here we have the limit of color subtraction.

A similar effect is obtained if inks are not mixed, but are superimposed one on top of the other. If a thin layer of yellow ink is coated above blue ink or vice versa, we also obtain green, as can be readily seen from the scheme given in Figure 69.

If intersecting screens are printed in different colors, both additive and subtractive color mixing is involved. Where the elements of the grid are superimposed on each other (in the places where they cross) we have subtractive mixing, as in all cases where inks are superimposed on each other. In those places, where the screen elements do not cross but are alongside each other, we deal with optical additive color mixing.

Assume that two intersecting 34-line screens are printed on each other, one azure and the other yellow. In the places where the screens intersect each other, there will be a superposition of the inks one on top of the other, and as seen above, the paper will reflect green rays. Where the screen elements do not intersect, but are alongside each other, they will reflect azure and yellow rays, which will become optically mixed to give a white-green color. Thus, when azure and yellow screens cross each other, the sensation on the whole will be that of a green color, red and yellow will give an orange color, and red and blue will give a violet or rose-violet color.

It must be borne in mind that actually all these processes are considerably more complicated than described here. The complication of the processes is due at least to the fact that the maps are printed with inks having a color that is different from the spectral one, and that the action of the inks is accompanied

by the action of the paper, which also has a certain color and undoubtedly affects the overall result.

To establish the necessary combination of colors so as to obtain the hues specified for the map (this is usually done when preparing the schedule for the color design of the map), it is not enough to know merely the laws of additive or subtractive color mixing. It is also necessary to know the spectral composition of the color reflected by each ink.

The inks used in offset cartographic printing are not spectrally pure and are always more or less contaminated by colors that do not belong to them. Thus, for example, red offset inks reflect only from 65 to somewhat more than 80% of red, and in addition reflect a considerable amount (from 7 to 20%) of blue rays and from 10 to 20% or more of green rays, which they should not reflect at all, while some green inks reflect up to 40% red rays. Blue inks reflect up to 20% and more of red rays, etc. The Division of Cartographic Polygraphy of the TsNIIGAIK has determined the purity of the inks used at the present time for offset cartographic printing, in accordance with the composition of the colors reflected by each of the inks. The results are given in Table 17.

TABLE 17

Serial No	Color of ink	Catalogue No of ink	Percentage of light reflected		
			Blue	Green	Red
[1]	[2]	[3]	[4]	[5]	[6]
1	Red	203	7	11	82
2	Red	211	8	11	81
3	Red	212	14	21	65
4	Red	126	8	12	80

[1]	[2]	[3]	[4]	[5]	[6]
5	Red	219	8	12	80
6	Red	229	15	10	75
7	Red	232	20	11	69
8	Red	275	14	14	72
9	Orange	104	6	21	73
10	Yellow	564	5	43	52
11	Yellow	589	9	50	41
12	Green	431	36	45	19
13	Green	435	14	43	43
14	Azure	363	47	32	21
15	Azure	364	51	30	19
16	Azure	365	44	36	20
17	Azure	368	47	32	21
18	Azure	369	44	33	23
19	Blue	311	59	19	22
20	Blue	342	47	31	22
21	Blue	345	51	30	19
22	Blue	346	48	31	21

From the above table it is seen that not all the inks used for offset printing are spectrally pure and are contaminated to a lesser or greater degree by extraneous colors.

The percentage proportion of the different colors that can be reflected by the inks is given only approximately in the table and a precise laboratory check may naturally give results that are different to a certain degree. However, these changes will not change the overall picture substantially.

We thus see that it is necessary to employ the assortment of inks at our disposal carefully and thoughtfully, particularly in those cases, when it is necessary to use different combinations of ink.

The same branch of the TsNIIGAIK has plotted curves for all the inks listed above, and in addition for ink No 631 (brown) and 745 (violet). These curves characterize the absorption of various wavelength by these inks (the values of absorption are marked on the ordinates of these graphs) (Figure 70). The curves make it possible to estimate the capabilities afforded by each ink so as to permit a more correct selection of ink for the printing of each actual map.

If, for example, it is necessary to obtain a green ink by mixing, the best for this purpose of all the above inks will be azure Nos 363 and 365 and yellow No 589, for they exhibit almost no absorption and consequently almost maximum reflection of the green rays (with a wavelength from 500 to 530 millimicrons). Azure ink No 364, for example, is less suitable, for it absorbs to a considerable extent the green rays, and consequently reflects them in smaller amounts.

Comparison of the curves leads to conclusions concerning the capability and advisability of using one ink or another. Green No 431, for example, is better used if a green hue, closer to the spectral one, is required, for it is better than ink No 434 in absorbing more non-green rays, and therefore reflects less of them, particularly in the long-wave portion of the spectrum, which indeed contaminate ink No 434.

45. Phenomena of Color Contrast

Most maps are published in many colors. Therefore it is very important to select correctly the colors with which the individual areas of the map are colored. In this connection, the phenomena of color contrast assume a certain importance.

Color vision is caused by physical-chemical processes occurring in the retina of the eye and transmitted by the nervous system to the cranial brain. Naturally, a certain amount of time is necessary to produce a summation of color during which these processes take place and during which the corresponding stimuli are transmitted to the brain. In exactly the same manner, the sensation of color cannot stop instantaneously with the cessation of the action of the stimulus but continues for a certain time. Any stimulation of the color analyzers leaves a trace for a certain period of time, which is called the after-image.

The after-image can be either positive, if it corresponds in hue and brightness to the stimulus causing it, or negative, if it is opposite in hue or brightness to the stimulus. A negative after-image takes place after observing a chromatically colored tone and shifting the vision to an achromatic background. Thus, after a green color acts on the eye, the achromatic background will appear to have a rose color for a few instants.

The change in colors that is perceived by the eye as a result of the action of certain other color stimuli is called the after-image contrast color.

The after-image contrast colors are close to the complementary colors of the stimulus, but are not always the same as the complementary colors.

Only in the case of red and green are the after-image contrast colors the same as the complementary colors.

The change in colors under the influence of other colors that surround them or that are in contact with them is of great importance. This phenomenon is called the simultaneous color contrast.

Any color appears brighter if it is surrounded by a darker background, and vice versa it appears darker if the surrounding background is brighter. This phenomenon applies both to achromatic as well chromatic colors. A yellow circle, for example, appears brighter against a dark background than against a light one. If a strip of yellow paper is placed with one end on a white field and with the other on a dark field, the end of the paper lying on the dark background will appear brighter than the end lying on the white background. This simultaneous contrast is called brightness contrast, for in this case all that changes is the brightness and the color hue remains as before.

But if a gray piece of paper is placed, for example, against a green background, it will appear slightly rose colored; a yellow paper acquires an orange hue on a green background; red becomes more saturated etc.

Such simultaneous contrast by which colors change their hue or saturation is called simultaneous chromatic contrast.

It is customarily assumed, with a certain approximation, that any color which is surrounded by another chromatic background experiences a change towards the color that is complementary to the color of the background.

Consequently, any chromatic color will appear more saturated if it is surrounded by its complementary color, and vice versa, it appears less saturated if it is surrounded by a more saturated color of the same hue. With this, it was established in practice that blue and green colors give the strongest contrast. By way of an example we include Table 18, which characterizes the influence of the simultaneous contrast on the color field and which may be of a certain practical value [15].

TABLE 18

Color	Neighboring Color	Effect of One Color on the Other	
Red	Orange	Red becomes yellower	Orange becomes gray-green
Red	Green	Tone of red unchanged, but red becomes brighter	Green does not change in tone, but becomes brighter
Red	Blue	Red becomes more orange	Blue becomes more green
Red	Violet	Red becomes orange	Violet does not change noticeably
Green	Orange	Green becomes more blue	Orange becomes more yellow
Green	Blue	Green becomes olive colored	Blue becomes more violet
Green	Violet	Green becomes more yellow	Violet becomes more blue
Orange	Blue	Orange becomes more red	Blue becomes deeper in tone
Orange	Violet	Orange becomes greener	Violet becomes more blue
Violet	Blue	No noticeable change	No noticeable change

Any number of colors arranged in a row produce the phenomenon of the simultaneous color contrast, i.e., each influences the hue or the saturation of the other with the color occupying the greatest area exerting the strongest contrasty influence. The simultaneous color contrast manifests itself most at the edges of color areas that are in contact with each other. This contrast is usually called the edge contrast.

Publishers of maps, working in color design, must take into account the fact that the warm and bright colors appear to be closer to the eye compared with cold and dark colors which appear to recede somewhat. This property of warm and bright colors is used in the design of scales of hypsometric coloring of the relief with illumination from above, which in many cases produces a beautiful plastic effect. If this phenomenon is not taken into account the map will appear, so to speak, steplike: some color areas appear to lie closer to the eye and other areas farther away from it. This causes the map to be noticeably spotty.

Of certain importance also is the property of the human eye of perceiving chromatic and achromatic areas as figures against a surrounding background. In this case a smaller area is perceived as a figure and a larger area is perceived as a background. In Figure 71 the eye perceives either a white cross against a black background, or, to the contrary, a black cross against a white background. But if the areas of the drawing are made unequal the smaller is perceived by the eye as the figure, and the larger as the background (Figure 72).

Finally, map publishers should become acquainted with certain aspects of color harmony since the harmonic combination of colors on the map is of great significance. The map should not only be an accurate drawing, but should be beautifully designed and have an attractive external appearance, stimulating a desire to become acquainted with its contents.

Disregarding the peculiarities of individuals, it is possible to indicate the following laws. When coloring areas on

a map it is necessary to hold to the rule that the saturation of the colors should be inversely proportional to the area occupied. If a map contains small and large areas, the smaller areas should have the most saturated colors. In this case the greater the area, the less saturated should be its color.

For a map such as a political-administrative map containing many various colored areas to have as pleasant an appearance to the eye as possible, and for the colors to be combined with maximum harmony and quietness, the areas occupied by the individual colors of the map relative to the color tone should be inversely proportional to the wavelength. In practice this means that larger areas should be colored with colors in the short-wave portion of the spectrum, and smaller areas with longer wavelengths. Finally, one must bear in mind that an area occupied by any color should be inversely proportional to its brightness. This means, that if a map contains several different areas, colored in the same color (for example, rose), the greater area should be colored brighter, and the smaller areas darker. Otherwise the map will be spotty and unpleasant to the eye.

When selecting the colors for the map and during the polygraphic reproduction it is necessary to take into account all three rules, although the first one is naturally the most important.

In a map we almost always deal with many areas colored in different colors and arranged in a row. But it is known that not all colors arranged in a row harmonize with each other and it is therefore necessary to take into account the rules applicable to this case.

All combinations of color spots on the map can be reduced to combinations in pairs, in groups of three, or in groups of four.

When colors are combined in pairs, the most harmonic and pleasant impression is produced by colors that are adjacent in the spectrum, such as yellow and yellow-green, green and azure, etc, or else by colors that are far apart in the spectrum and also by complementary colors, for example red and blue-green, red-orange and blue, orange and blue-violet, yellow-orange and violet, yellow and red-violet, red and yellow-green, red-orange and green, orange and blue-green, blue and yellow-orange, blue-violet and yellow, violet and yellow-green, red-violet and green.

Less pleasant to the eye but also usable in the design of maps are the following color combinations: red-orange and yellow-green, orange and green, yellow-orange and blue-green, yellow and blue, yellow-green and blue-violet, blue-green and red-violet, red and yellow, green and violet, blue and red, blue-violet and red-orange, red-violet and yellow-orange, violet and orange.

Maps having many small outlines which must be colored in different colors can be produced with the following color combinations: red and yellow-orange, red-orange and yellow, orange and yellow-green, yellow-orange and green, yellow and blue-green, yellow-green and blue, green and blue-violet, blue-green and violet, blue and red-violet, blue-violet and red, violet and red-orange, and red-violet and orange.

When colors are combined in groups of three the tendency is to employ colors that are equally spaced on the color circle. Such colors may be red, yellow, and blue; blue-green, red-violet, and yellow-orange; red-orange, yellow-green, and blue-violet; orange, green, and violet.

When combining colors in groups of four it is necessary to hold to the same rule of equal spacing on the color circle between the combined colors.

In practical work it is difficult to produce exactly the above optimum conditions, and deviations are always possible. It is important that all the above laws of the action of light on the human eye be taken into account in the production of maps, and that they never be disregarded; this will lead to favorable conditions for improvement of their color design.

CHAPTER 15

GENERAL CONCEPTS ON TECHNICAL EDITING OF MAPS AND ATLASES

46. General Remarks

Technical editing of maps is a special form of editorial work. The technical editor directs all the work on the publication of the map (atlas). He exercises controls at all stages of the work, releases negatives and printing forms, whether original or machine-reproduced, for further manufacture, and determines their quality. The technical editor has full responsibility for accurate agreement between the map and the contents of the publication originals, and he therefore organizes a thorough-going proofreading of the correctness of the work at all its key stages (retouching of the negative, engraving work on the forms, etc).

Proofreading, inspection, and technical direction are only part of the work of the technical editor. Another part is the development of the technological plan for the publication of the map.

Modern polygraphic technology has at its disposal a great variety of means and methods for the production of printing forms. The technical editor should select from among these methods the ones that would permit obtaining the best results with a minimum expenditure of efforts and means, as applied to each actual map or atlas.

The development of the technological plan of the publication is a complicated creative process. In order to carry it out correctly from start to finish, the editor should know well not only the processes involved in the manufacture of printing forms, but also the content of the maps, and should have a clear idea of its peculiarities; for this purpose he must participate in its production long before the originals of the map are received at the publishing house. He should participate in the general editorial development of the map and particularly in the development of the problem of technology of its line work and color design. The editor always works on the map in close contact with the managing editor.

The work of the technical editor that pertains directly to the process of the preparation of the printing form comprises the following key stages:

- (1) receipt the originals and their evaluation;
- (2) development of the technological publication plan;
- (3) checking the quality of the negative;

- (4) proofing the retouching of the negative;
- (5) proofing the correctness of the engraving work;
- (6) directing the proofreaders in printing the color proof and its correction;
- (7) checking the correctness of the manufacture of the original printing forms and of their quality.

47. Receipt of Originals and Their Evaluation

Regardless of whether the technical editor is familiar with the map received at the publishing house or whether he encounters it for the first time, the editor's work on the map in the process of the preparation of the printing form begins with the reception of the publication originals and their evaluation in terms of the requirements imposed on the publication.

When the editor receives the publication originals of the maps or atlases at the publications office he may be faced with the following three typical cases, each of which imposes on the originals not only the general requirements, but also the specific requirements. These cases are:

1. All the elements of the contents of the map, including the names of the objects, are contained in a single original.
2. The elements of the contents of the map are drawn on different originals, with two cases possible thereby:
 - (a) all the line elements are drawn on one original, and all the legends are on another;
 - (b) the different elements of the contents are drawn on different originals, each individually or in small groups.

3. The publication office receives originals of atlases not in the form of whole printing signatures (this would correspond to one of the two cases listed above) but as individual originals for each small map. In this case, too, the drawing and the callouts of the content elements may be either combined or separate.

Each case imposes different requirements on the originals, which must be treated differently before they are put into publication production. However, publication originals must also satisfy general requirements regardless of how they are prepared. These general requirements are as follows:

1. The originals must be made on a material which would guarantee that the dimensions remain constant and would exclude the possibility of deformation on any noticeable scale.

To satisfy this condition, the drawing paper is pasted on an aluminum plate or at least on plywood before preparing the publication original. The solid base must be flat, so that the drawing can adhere to the pneumatic screen of the camera completely and uniformly. The paper must never come apart from the base.

2. The line elements must be drawn and the titles must be pasted on white paper. The paper must not be of a different shade even in the case when several sheets are pasted together to prepare the original, for this would deteriorate the quality of the printing forms. Nor is it permissible to employ drawing paper with a yellowish or gray color.

3. The line elements must be drawn with black india ink.

All lines, dashes, and dots, which make up the cartographic drawing, regardless of their thickness, should be dense without gaps and without gray or broken spots. The drawing must be sharp. The edges of the lines must be even without barbs. The surface of the drawing should contain no spots or damages in the forms of holes, scratches, etc, nor should there be any trace of glue. All traces of pencil and of various notes must be removed from the drawing and from the white margin of the original. The distances between neighboring hatching elements must not be less than 0.3 mm when reduced to the actual publication scale of the map.

4. The names of all the objects should be prepared in the form of paste-ons prepared by photographic typesetting. The paste-ons should have no smeared or erased letters, nor should there be any cuts adjacent to the ends of the letters. The cuts on the paste-on should be inclined so as to produce no shadows. The paper on which the paste-ons of the legends are printed should be white and if possible dull. No traces of glue should remain on the paste-ons.

5. Each original should be marked with the actual dimensions and also with the so-called theoretical ones -- corresponding to the dimensions of the sheet of the map in publication, multiplied by the magnification coefficient. The dimensions should be indicated in all six directions, i.e., on the four sides and the two diagonals.

6. Halftone originals (for example, wash-off relief originals) should be made with somewhat greater contrast than required to obtain a drawing on the final form. This is necessary for the

purpose of preventing excessive softening of the monotonic image by the subsequent photography, when the drawing is broken up into individual dots, and consequently, it becomes softer and so to speak washed out. It is particularly important for a half-tone original that it be made on a paper with an even tone, as white as possible, having no spots, traces of another drawing, notes, or other faults.

7. The blue-line traces on all the originals should be as actinic as possible (best light azure), so that they do not produce any image at all on a negative with a non-color-sensitive emulsion upon further photography.

8. The originals should be approved for publication by the corresponding responsible persons, including the editor of the map without exception, and signed by these persons.

If originals, with content elements that are drawn separately are received for publication and evaluation, they must meet the following additional requirements:

The dimensions of all the originals used for the same sheet of the map should be identical. The maximum tolerance in the dimensions of the originals are not more than 0.2 -- 0.3 mm on each side of the original. These deviations must have the same sign for all the sides and for the diagonals. Failure to satisfy this condition may cause map elements drawn on different originals to print out of register.

The internal outlines of the map or their corners must be drawn clearly on all originals.

If originals of atlases are received drawn not as whole printing signatures but as individual maps or groups of maps, it is necessary to satisfy, in addition to the above, also the following requirements:

The originals of all maps, located on the same printing signature, should be identical in dimensions and should have the same type of design. In this case all elements may be drawn on one or several originals; it is important that all the maps printed on the same signature should be made identically. Requirements that all originals be of equal size must be understood in that sense, that they must be drawn with the same magnification relative to their published dimensions.

The receipt of originals for publication is a responsible step, and the technical editor must therefore not approach this task formally. The quality of the line printed forms, and consequently, also of the printed map, is directly related to the quality of the original. It is impossible to obtain a good printing form from a poor original and no supplementary work on the negative or on the printed form can correct shortcomings in the original.

Together with the publication originals, the technical editor receives also auxiliary materials necessary for correct organization of the entire process of map publication. The most important of these materials of substantial significance are the colored original, dummies for the separation retouching of the negatives, and lithographic dummies for the engraving and other work on the printing forms.

The color original is a hand-colored copy sample of the map on which only the background portion is usually drawn, being the most complicated for the polygraphic reproduction. The colored original should give the fullest possible idea of what the published map will look like, and it is therefore necessary for the editor to pay particular attention to the preparation and acceptance. The technical editor must work jointly with the artist on the preparation of the colored original. The colored original must satisfy the requirement that it be reproducible by relatively simple polygraphic means and with a small number of inks as called for by the established plan. The success is best assured in that case, if the artist guides himself in the coloring by the color chart or scale of color combination used for offset cartographic printing.

The dummies for the separation retouching of the negatives are made on prints of the map, containing all the line elements included in each original. Different bright well-distinguishable colors are used to highlight on these maps the elements that should be printed in different colors. Since the dummies serve as a guide to the retoucher for the separation retouching of the negatives, and to the technical editor for the proofing of this retouching, the following requirements must be satisfied by the dummies:

- (1) all the separated elements must be highlighted sharply with colors that differ substantially from each other without any confusion;
- (2) the dummies must be thoroughly proofed, this being noted on their margins with corresponding signatures;

(3) the dummies must be approved for further manufacture and signed by the responsible persons.

Lithographic dummies are also prepared on prints containing all the line elements. These should show with well-distinguishable colors the areas that are printed in different colors. Such dummies must meet the following requirements:

(1) The dummies must be prepared with prints, containing all the line elements (with the exception of lettering) contained on the map, regardless of the number of originals used to make up the map.

(2) The colors should be bright, well distinguishable from each other, and transparent, so as not to cover the line drawing. Hypsometric maps should show separately each coloring hypsometric layer, regardless of the technology used in the production.

(3) The dummies must be thoroughly proofread, and signatures to the effect should be placed on the margin.

(4) They should be approved for future manufacture and signed by the responsible persons.

48. Development of the Technological Plan for Publication

Before proceeding to issue the originals of the maps for publication, the technical editor should outline a clear plan of preparation, including all the processes, so as to insure the publication of maps of high quality with the least expenditure of labor and materials. Such a plan is the technological plan for publishing the map (or atlas).

The technological plan for publication spells out the entire technological process, and therefore the manner in which this plan is compiled affects not only the quality but also the economic results of the work. It follows from this that the technical editor must approach the development of the technological plan with particular seriousness and care. Here he must carry out the development bearing in mind the following:

(1) It is necessary to select the most advanced of all the technical means at the disposal of the enterprise and of all the procedures and methods known to the workers, so as to insure a high grade of production.

(2) The authorization of the work and the technological means must be such that the publication costs are at a minimum.

(3) The technological scheme should be the simplest and best understood by all performers.

(4) The duration of the production cycle should be the minimum possible. Satisfying this condition is particularly important for a short production cycle is advantageous not only economically but also because a prolonged production cycle requires corrections, sometimes serious ones, to the contents of the maps, and this deteriorates the quality and increases the cost of the work.

The form in which the technological plan of publication is compiled is of no substantial significance. In most cases it consists of the following divisions:

1. General information concerning the map (atlas), including data on the number of signatures and their dimensions, the number of colors used in publication, the number of originals used to prepare the content elements, the supplementary materials to be added to the publication originals (dummies, color original, etc), and other analogous information. The editor always has these data in ready form and all he has to do is to include them in the plan.

2. Spelling out the actual tasks of all the subdivisions (photographic, copying, retouching, etc), as required by the technological process used for the publication of the particular map. This section of the plan actually determines the volume and cost of the work. It is worked out by the technical editor as completely as possible. It indicates the number of negatives that must be prepared, the method of their preparation, the character and sequence in retouching the negative, the method of preparing the "phantom outlines" and their number, the character and sequence of the engraving operations, the character and scope of the photo-copying work, the work that must be performed on proof presses, the methods of correction, and the stages in which it should be performed, and other analogous data. Even the above list alone of the data contained in this section of the technological plan for publication shows how seriously it should be thought out by the technical editor.

3. Color schedule, which predetermines the color design of the future map.

The color design for the map is selected long before it is submitted for publication. This work should be a joint effort of

not only the map editor and the artist, but also the technical editor. For the map to be readily reproducible as close to the original as possible the choice of colors should be carried out in the following manner.

Before coloring the original the artist should study the color chart or the scale of color combinations printed on an offset press so as to gain an idea of the color combination with which his projected color rendering can be reproduced. From there on, the artist works on the color design of the map only with color samples contained in the chart or on the scale.

In this manner, the artist duplicates with water color the specimens of the color as printed by the offset inks. There are times when the artist develops a color design and colors the original without making allowances for the available assortment of offset inks and for the possibilities of their combination; this is wrong and cannot lead to good quality. The polygraphic means available for planographic printing cannot always reproduce in practice the artist's water-color original of the map.

If the artist uses the previously-printed scales in coloring the original there is no difficulty in preparing a color schedule. All that is necessary is to establish the combination of inks with which to reproduce the tones selected by the artist and to reproduce them in the color schedule. This can be simplified considerably if all the combinations in the color chart or on the scale are numbered and the artist marks these numbers on his original.

In those cases when the technical editor did not participate in the development of the color design and the artist did not use

the color chart or the ink-combination scale in the preparation of the colored original, the technical editor is faced with the complicated problem of compiling a color schedule on the basis of the colored original.

The color schedule must be worked out by the technical editor in its final form, for it is impossible to introduce substantial changes during the performance of the engraving work without seriously damaging the quality of the map.

To prevent errors in the color schedule in the publication of new and complicated multi-color maps and particularly atlases the technical editor must first check the color combination selected by him. This verification is best carried out by printing a special scale containing the solid color and various screens. By printing on a single print inks of various colors, the technical editor convinces himself whether the desired effect is produced. After this experimental work is performed and the technical editor is convinced of the color combination with which the colored original can be reproduced, he can finally work out the color schedule.

In all cases, the technical editor must observe the following conditions during the development of the color schedule:

(a) The number of colors should be at a minimum. An excessive number of colors only makes the publication more expensive, and as a rule, increases the waste of paper without improving the quality.

(b) At the joints between the sheets of multi-sheet maps it is necessary to avoid colors that overlap each other and to use pure colors where possible. This is particularly important in the coloring of areas located on several sheets of the map. A combination

of not more than two colors is permissible; a large number of colors sometimes causes different hues to be seen on adjacent maps, thereby deteriorating considerably the quality of the map.

The color schedule, together with the lithographic dummies or the colored original, serves as the material used by the engraver in the preparation of the background printing forms.

The preparation of the technological publication plan concludes the preparatory work of the technical editor. This is followed by the stages of the operations performed by him already during the actual process of the preparation of the printing forms.

49. Checking the Quality of the Negatives

It is usually assumed that the shift foreman of the form-preparation shop receives the negatives from the photographer and checks them, or else this work is performed by the foreman of the photographic division. This is correct, but is not always enough. Approval of negatives for further manufacture affects the entire subsequent course of the work, particularly the quality of the finished map. This is why the technical editor is far from being indifferent to the quality of the negatives.

In the publication of maps with fine and complicated drawings, the technical editor must personally check the quality of the negatives and positives, before forwarding them to further manufacture; in this operation he must establish the following:

- (a) the dimensions of the drawing;
- (b) the quality of the image.

Checking the dimensions of the drawing on the negative is of particular importance. When the technical editor checks the dimensions of the drawing on the negative he may encounter the following cases:

(1) The negative contains the entire map as a whole, all the negatives for the line elements are photographed from a single original. In this case it is advisable to duplicate the negatives by contact printing, a method that the technical editor should introduce in cartographic practice. In addition to being cheaper than photographing each individual negative, this method makes it possible to retain equal dimensions on all the negatives.

Such a result, however, may for various reasons be unattainable and each negative may have to be obtained by individual photography. In this case the dimensions of the drawing on the negative must be checked without exception.

Since all the negatives for a single map are photographed with a single setting of the camera, the verification may be limited to comparing the dimensions of the drawing on four sides of all the negatives. The dimensions obtained on different negatives should not differ from each other by more than 0.2 -- 0.3 mm in one direction. It is important that the difference in dimensions be a minimum between those negatives, which are intended for the elements requiring particularly accurate registry with each other (hydrography and relief or railroad net etc).

2. As in the first case, the negative may contain the entire map, but different negatives have been photographed from different originals. To check their dimensions in this case one must not

measure the four sides of the map alone; it is necessary to measure also the diagonals and in this case not four, but six measurements are involved. The verification must be particularly careful in cases when the drawing of the map is separated into more than two originals.

3. The negative does not show the entire map but only one of its parts, as is encountered in the publication of multi-sheet maps. In this case it is necessary to check with particular care the dimensions of those sides that have to be joined with others. Depending on the character of the drawing various discrepancies may be permitted between the dimensions of these sides but they must not exceed ± 0.3 mm.

4. Finally, the negative contains not one but several maps. If all the negatives were photographed from a single original the verification reduces to the procedure described in the first two items above. But if the negatives are photographed from different originals or from originals mounted one on top of the other the check on the negative dimensions becomes more complicated. The technical editor must check whether the dimensions of the different negatives correspond to each other and whether each individual map is located directly on each negative. For this purpose, in addition to measuring both sides and the two diagonals it is necessary to check selectively on all the negatives the mutual placement of the individual maps. The negatives should be measured with an ordinary rule between the corners of the internal frame. In individual cases these measurements can be carried out between points contained on all the compared negatives. Such points may be, for example, the intersections of the lines of the geographic grid.

The technical editor can approve for further work only those negatives which insure that all the entire contents of all the line elements are properly registered on the map.

Checking the Quality of the Image on the Negative. The quality of the image on the negative is very important for further preparation of the printing forms. The negatives approved for work should contain a dark dense and opaque background, non-actinic shadings, transparent lines, points, and dashes, forming the cartographic drawing. The drawing must have sharp edges and must be separated from the surrounding background with maximum contrast. The same map-content elements should be identical in the different portions of the negative (as seen by visual inspection).

When estimating the quality of the negatives the technical editor should take into account the fact that it is impossible to obtain a good printing form from a poor negative; neither the retoucher, nor the copy operator, no matter how skilled a craftsman he may be, is in position to correct the faults of the negative.

After checking that the negatives are fully satisfactory both with respect to dimensions and quality the technical editor may approve them for further manufacture.

It is most advantageous to check first the quality of the image, and then to check the dimensions of the image on negatives and positives of good quality.

50. Proofing the Retouching of the Negative

The next stage in the work of the technical editor is the proofing of the retouching of the negative. The need for thorough

proofing of separation retouching of the negative is determined by the fact that the errors committed on the negative during the separation retouching cannot be corrected without damage to the quality of the map on either the positives, or on the negative forms.

To check the correctness of the separation of the drawing on the negatives the technical editor may use the following procedures:

(a) Direct checking on the negative, which can be used if the maps consist of simple drawings. In this case the negative is checked by looking through it on a retouching stand (table) from the side of the glass where a direct image of the drawing is visible and where it can be compared with the separation dummy. The technical editor may make his notations directly on the glass, by circling with retouching ink the places to be corrected. This is the simplest method of proofing the separation retouching of the negatives and can be used for wall-type classroom maps.

(b) Checking against a print made from the retouched negative. The technical editor compares the print with the separation dummy and notes his remarks on the margins of the print. This proofing method can be used for maps in which the drawing is of medium complexity, for example, in classroom atlases. The simplest way is to use for proofing a black print on paper, obtained by copying the retouched negatives on blue print paper.

(c) Checking by registry on the red outline. To proof by registry on the red outline, the printing forms of the outline

and of all the separation negatives are copied. The image from the outline printing form is printed on paper in red color. Next, all the printing forms obtained from the separation negatives are printed on the same print in black. If retouching has caused any part of the separation negative to become blocked up, a red line will remain in this place, while the entire remaining drawing will be covered with black ink. The editor notes his comments on the margin of the print.

(d) Checking by preparing a line proof. Proofing by registry on the red outline permits rapid detection of all the drawing lines that have been covered by mistake on any one of the negatives. To determine whether the negatives contain erroneous elements of the drawing the most reliable method is to print a line proof. Printing forms are copied from the retouched negatives and are used to print line proofs in different colors (best those that will be used for publication of the given map, but others can also be used). Thorough checking of the line proof and its comparison with the separation dummies enable the technical editor to check the quality of the separation retouching of the negatives. He notes his remarks on the margins of the print. The line proof is usually printed in parallel with registry on the red outline. The printing of the line proof, as well as the registry on the red outline, is best used only for maps having the most complicated drawings.

In all cases, no matter what method is used for proofing the corrections must be checked personally by the technical editor on the negatives and only negatives about which there is no doubt concerning the separation should be approved for further production.

51. Proofing the Correctness of the Engraving Work

The correctness of the performance of the engraving work must be checked to determine that the forms are ready for the preparation of the color proof. Here it is necessary to check the quality of the drawing obtained on the form, and the accuracy with which the drawing is prepared.

Checking the Quality of the Drawing. The form as a rule contains solid tones and screens, and before proceeding to check the accuracy with which the drawing is prepared the technical editor should decide whether the printing form is suitable for further manufacture with respect to the quality of the image. The check should disclose the following:

1. Whether the solid drawing portion is dense, whether there are gray spots, and whether any corrections are necessary.
2. Whether the screens are of the fineness called for by the technological plan for publication and whether the orientation of the screen is correct. It is also necessary to check the external appearance of the screen, whether there are over-copied, gray, or broken spots.
3. In the case of multi-sheet maps it is necessary to establish whether identical grids are used for the same colors in all the sheets of the maps, whether the orientation of these screens are identical, as provided by the technological plan for publication.
4. Whether the nonprinting areas are clean on the forms, containing no traces of shadows or dirt.

All these checks are preliminary and can be performed directly on the forms. It is most advantageous to carry out this work before the forms are ready for the preparation of the registry and quality prints. Even after such a superficial review, the technical editor can already reject the poor-quality forms. If a visual check discloses faults that can be corrected without damage to the quality of the form, the form must be returned for correction and sent for preparation of registry and quality-control prints only after correction. The final check on the quality of the form is made by the technical editor by reviewing the quality-control prints together with estimating the accuracy of the drawing from the registry prints.

Checking the Accuracy of the Drawing. The engravers place on the form solid tones and protective coatings in places where they will copy screens or introduce them in some other manner. This work must be performed with particular care, for its accuracy determines the registry of the ink when printing the run.

If the maps are drawn with heavy outlines and with large-scale drawings the accuracy of the image can be checked directly on the form, comparing it with the lithographic proof or with the colored original. The correctness of the engraving work of maps containing complicated drawings with fine details can be checked only from registry prints.

To obtain a registry print, the outline of the line drawing, containing all the line elements, is printed with some dark color (black, dark brown, or dark blue). Then a bright, clearly noticeable ink, which is transparent and which does not cover the dark lines

of the outline (red, green, azure) is used to print the background colors from the forms. Each form is printed here on a separate print. The check consists of establishing by comparison with the lithographic proof or with the colored original whether the engraver has placed properly the solid tones or whether he blocked the places for the introduction of the screens. The registry prints should be printed from dry forms and best on paper which has already been printed from one side so as to eliminate as much as possible noticeable deformations in the dimensions of the paper.

The drawing on the form should always be brought to the center of the marker denoting its boundary. It is not permissible not to bring the drawing to the marker; no tolerances are permitted here. The drawing must not deviate more than 0.2 mm beyond the marker. The technical editor notes his comments on the margins of the registry print.

Together with checking the accuracy of the drawing, the technical editor checks finally and estimates the quality of the image using the so-called quality-control prints or scales. The quality-control print is printed from the form with black ink; it should be printed evenly from the entire form and its ink should be in a thin layer. The quality-control print is used by the technical editor to check the quality of the image the same as in the preliminary check, but here he does it not by looking on the form, but on the basis of the print.

It is important to decide what can be and what cannot be corrected on the printing forms. Concerning these problems, the technical editor must guide himself by the following rules:

- (1) It is possible to add solid tone on the form in any size.
- (2) It is possible to remove from the form the solid colors and the grids, using in each individual case the corresponding measures and methods.
- (3) It is possible to add a screen on an isolated area of the form that is free of any drawing.
- (4) It is impossible to extend a screen on the form.
- (5) It is impossible to place a screen on those spots on the drawing, where a drawing was previously located, regardless whether the latter is solid or screened.
- (6) It is impossible to clean screens on the forms with engraving needles or with other tools.

As can be seen, the possibilities of correcting a drawing on the forms are quite limited. The technical editor must know exactly that it is better to make a poor form over right away rather than lose time and material on correction.

The correction of the forms should be checked by the technical editor personally. This check must be carried out directly on the forms and only in certain cases is it necessary to register again on an outline. Each additional processing of the printing form and each print drawn from it deteriorates its quality and there is therefore no need for abusing various types of registry prints, printing quality-control scales, etc; one must resort to it only in absolutely necessary cases. With this, the technical editor should guide himself by the following rule: all that can be checked directly on the forms should be done so.

The proofing of the background printing forms should be done only once and for all. Multiple proofing and corrections of the same form are not permissible; experience has shown that in such cases the forms are frequently spoiled even before the color proofs are printed from them.

52. Guidance for Proof Printers When Printing the Colored Proof

After all the printing forms have been checked and the necessary corrections have been made the color proof of the map is printed.

The printing of the color proof is an important key stage in the process of map publication not only because the proof enables the cognizant organizations to decide finally and approve the printing of the run, but also because the color proof should serve as a standard for printing the entire run.

When printing the color proof the technical editor must insure the following:

1. That the printed copy of the map corresponds to the color original or to whatever standard has been used as the basis for the background coloring at the development of the technological plan for publication.
2. High quality of drawing, so that the prints of the proof can serve as standards for printing the run.
3. Maximum possible registry of the colors, so that the proof can also serve in this respect as a standard when printing the run.

A colored proof can be considered satisfactory only when the above three conditions are satisfied. If at least one of these is not satisfied the color proof cannot be accepted by the technical editor and should be redone.

During the printing of the proof the technical editor may encounter the following cases:

1. The colored original and the graph of tonal design are compiled in accordance with the same color charts or color-combination scales. In this case the technical editor should help the printing press operator as much as possible to match the colors with those in the color chart or in the scale. This is simplified if ready-made, unmixed inks are used for most backgrounds.

2. The colored original is made by the artist without adhering to any definite combinations of offset inks, but before the final compilation of the color schedule, the technical editor checks the possibility of obtaining all the tones, or at least the principal ones, by conventional color combination. Such a check, as indicated above, can be made by printing the combination scales of selected inks and comparing them with the colored original. In this case the technical editor should help to choose the inks not by matching them against the color chart, but against a preliminary scale which is used as the basis for the compilation of the color schedule.

3. The color schedule was compiled without preliminary checking, and the color original was prepared with arbitrary colors. This places before the technical editor many important complicated problems.

It is necessary to reproduce the colored original during the printing of the colored proof, using already finished printing forms by varying only the hue, brightness, and saturation of the inks. The particular complexity lies in the fact that it is necessary to obtain for each map several dozens of various different hues and to use thereby the minimum number of inks. As a rule, in these cases the technical editor must experiment during the printing of the proof by testing various inks, thereby considerably complicating his work and the work of the press operator, and in spite of all, it is almost impossible at any time to reproduce exactly the colored original.

In all cases, the technical editor tells the press operator what ink to use, both relative to the tone as well as relative to the registry of the drawing.

The sequence in which the colors are printed is in itself of no importance, although many are of the opinion that it is best to use the same sequence in superimposing the ink during printing the color proof as used when printing the run. It is necessary to adhere rigorously only to the following rules:

(a) If covering inks (for example, chrome) are used in the map, they should be printed first and the transparent inks should be printed over them. Such a sequence of printing guarantees purer tones obtained by the combination of different inks.

(b) When printing the proof of a multi-sheet map it is necessary to print the same ink absolutely in sequence in all sheets composing the map to prevent possible differences in shadings of the same color on different sheets. It must be borne in mind

that sometimes slight deviations in the shading leads to sufficiently strong and noticeable deviations from the expected tones when this ink is combined with others, and in any new mixing of the ink, or even if using a ready-mixed ink, diluting with drying oil or whitening may cause slight deviations in the hue, brightness, or saturation. Printing the same ink in sequence on all sheets making up the map is convenient not only from the point of view of quality but also of economy, for it permits the press operator to reduce the amount of time consumed in washing off the color plate and rollers, mixing or diluting the ink, rolling it over the color plate, and also other auxiliary operations.

(c) Each new color is printed only after the previously-printed ink has dried. It is then unnecessary to powder the prints with talcum powder or other material frequently and abundantly.

Unfortunately, powdering the prints during the printing of the colored proof is unavoidable; otherwise several weeks would be consumed in printing each proof. In order not to affect the quality adversely, the powdering must be carried out only before the printing of the new ink when the previously-printed ink is already partly dried. Powdering is undesirable for the following reasons:

1. The purity of the tone is lost; the colors appear dim and faded.
2. When placing the next coating of ink, the latter, owing to the accumulation of a layer of talcum on the print, is printed spottily, thereby deteriorating the quality of the proof. It is therefore necessary to carry out the necessary preparation before the printing, to make sure that the printing of the proof can continue without interruption.

Every possible measure should be taken to reduce to a minimum the effect of the deformation of the paper. For this purpose the proof should be printed with a dry printing form. The paper is best passed under the press of the printing machine once or twice before printing so as to eliminate some of the harmful effect of the internal stresses remaining in the paper after preparation and finishing.

(e) All line elements are best printed before the background elements. The only possible exception is wash-off relief. The latter is best printed after all the inks are superimposed; in this case it is possible, by varying the color and saturation of the ink, to influence the external appearance of the map.

The legends [letters] on the map are frequently printed last. This sequence cannot be considered good, for in this case the fine elements of the type must lie on the previously-printed layer of ink which in addition contains a certain thickness of talcum. This causes the printing of the letters to become uneven under such conditions and many fine elements disappear and the quality of the color proof is noticeably deteriorated.

The technical editor must very carefully proof the finished color proof. The checking must be very thorough because this is the last stage in which it is still possible to correct errors and shortcomings, the elimination of which is impossible when printing the run. Therefore, even though the technical editor has already proofed the separation retouching of the negatives and engraving work, all work must be done over again in full, using all the materials involved (originals, dummies, colored original, etc).

The sequence of proofreading the color proof can be arbitrary, but the proofing must establish the following:

1. Are the line drawings of the map elements correctly reproduced; are there any elements that are shown in the wrong color; are there any line elements entirely omitted and not shown on the map, and finally, are there line elements consisting of two or several negatives and consequently printed in several colors.
2. Are the line elements sufficiently well printed; are there any gray, broken, spread lines or call-outs; are all the line elements, including the signatures, thoroughly distinguishable and clearly legible.
3. Is the color original well reproduced and are the areas of the map, colored in different colors, sufficiently distinguishable from each other; is there a good agreement between the coloring of the map and the corresponding colors indicated in the legend.
4. Is the coloring correctly done; does the color extend in all areas to the outlines on their boundaries; are there any gaps in the coloring of the background elements and are there any wrongly-colored areas.
5. Are all the line and background elements in good register.
6. How well are the background inks applied; do they run evenly from the start of the solid tone, and are there any gray or spreadout dots.
7. Is there any dirt, spots, or other shortcomings on the map itself as well as on the margins.

The technical editor marks his notes on the margins of the print of the colored proof.

53. Checking the Corrections with the Printing Forms After the Color Proof

Any correction of the printing form is undesirable; it deteriorates the quality. However, it is impossible to completely avoid correction of the printing forms in practice, and it is therefore important to carry out the corrections in such a manner that they have the least effect on the quality of the forms.

After receiving the comments concerning the color proof, the technical editor should draw up a plan for carrying out the corrections called for by these comments. In the compilation of the plan it is necessary to be guided by the following rules:

1. Corrections to the line elements must be made on the negatives. The corrected negatives are used either to copy directly machine printing forms for printing the run, or else new original printing forms are prepared for subsequent preparation of machine forms.

If the forms of the line elements, from which the colored proofs were printed, cannot be corrected or used for printing the run and it is necessary to copy them anew from corrected negatives, it is advisable to check their contents by printing a combined print of the new and old form. This makes it possible to check rapidly and, what is more important, more reliably the contents of the newly-copied form and establish simultaneously how the corrections indicated on the color proof have been effected.

2. Corrections to the background elements are made on the forms, with the technical editor taking into account the extent to which the forms can be corrected, as indicated in Section 51.

When preparing the plan for correcting the background printing forms it is necessary to bear in mind that forms requiring large corrections -- changes in the number of lines, direction, or percentage ratio of the screens, introducing screens instead of solid tones, adding screens to outlines, etc -- are best done over again rather than attempting to correct them. Doing the form over again in this case is better not only from the point of view of quality but also of economy, for in the final analysis it will cost much less.

Minor corrections to the line and background elements can be checked by the technical editor directly on the negatives or on the forms. To check the correctness of the correction of many errors, the technical editor uses the same methods as in the proofing of the separation negatives and engraving work on the forms.

Cases may be encountered when errors in the line elements are such that they cannot be corrected on the negatives. For example, if many changes in the administrative arrangement or in the transcription of many names occurred between the preparation of the color proof and the start of printing the run. In this case it is possible to employ the following measures: (1) correcting the originals and preparation of new negatives from them; (2) preparation of special supplementary originals and negatives from them with subsequent copying of the corrected image onto the printing form.

The correction of the originals and the repetition of all the photo-reproduction and retouching work all over again is

preferable because it makes it possible to obtain a high grade printing form, leaving a single corrected original and a negative that is in full agreement with it. When correcting the legends that is what is really done in most cases. This method is used considerably less in the correction of contours, for every time the photography is repeated it is difficult to obtain negative dimensions that are in full agreement with those previously obtained, and it is therefore difficult to use the background printing forms previously prepared on the basis of the old contour.

In order not to do the background printing forms over, thus consuming much time and material, an attempt is always made to correct the contours on the negatives.

Supplementary originals are prepared in those cases when the corrections cannot be made on the negatives and it is impossible or unadvisable to repeat all the photo-reproduction work. The need for new originals may also be dictated by the fact that these originals are missing at the enterprise publishing the map.

All the corrected contours are drawn on the supplementary originals and all the corrected legends are pasted on. A negative is prepared from this new original. The entire drawing that is subject to correction is blanked out on the old negative. A combination copy is made from both negatives on a single plate and a complete printing form is obtained for the required line element. This method is used in particular in those cases when it is necessary to correct large numbers of legends (for example, their transcription), or to relocate the legends.

Quality-control prints (scales) should be printed from all

the corrected printing forms after suitable treatment and used by the technical editor to establish the suitability of the form for printing the run. These scales made of the original printing forms, checked and signed by the technical editor, serve as future standards for comparison with quality-control prints (which in turn serve also for proofing the contents), printed from the machine printing forms. Their quality must therefore be high in every respect.

54. Records Kept by Technical Editor

It is important that the technical editor keep records of all his activities, particularly in the key stages. For this purpose the technical editor must keep a map file and a journal. Both documents are not only very important in organization of the work, but play a purely technical role in the republication of maps or atlases, thereby making it unnecessary to develop a technological publication plan every time, etc.

The technical editor keeps in the map file specimens of the line and color design (if such are prepared during the editorial preparation of the map), line proofs, proof prints ("red outline" combined prints and combinations "in their proper colors" for checking the engraving work, quality-control prints of the scales, etc), color proofs -- both clean, as well as those with all the remarks noted and used to correct the negatives (positives) and printing forms (so-called "summary prints") -- and also all the correspondence relating to the map after approving the color proof. If the line proof was approved at any stage, the map file should contain a copy of the remarks on the line proof, made during the approval.

The map file should be kept in the technical editor's office. The technical editor's work journal is just as important, and perhaps even more so for reprint jobs. The journal may be kept in any form. It is merely important that it contain everything of significance performed by the technical editor in the development of the technological plan for publication and its realization. By writing down all the stages of the work, the technical editor produces excellent material for reporting his experience, which is essential for further improvement of the technological process of map publication.

The journal must contain the following records:

1. Acceptance of the original. It is necessary to give a brief qualitative evaluation of the originals and of all appendices, noting what shortcomings were observed and what difficulties these shortcomings may cause in the publication.

2. Development of the technological plan for publication. It is necessary to record what methods were selected by the technical editor for the montage of the originals (where necessary), reasons for the selection, and what preparatory work (printing of color combinations, examination of the color chart, etc), and their results, what methods were chosen to reproduce the line drawing and for what reason, the principle underlying the development of the color schedule, and the basis for the choice of the final version of the technological process.

3. Proofs and inspections during the preparation of the line and background printing forms. It is necessary to indicate what errors the technical editor encountered during the process of

control and how they were eliminated, and to evaluate the quality of the negatives (positives), and all printing forms should be given.

4. Printing the color proof. This should reflect the joint work on the part of the technical editor and the press operator. It is necessary to indicate the sequence in which the color proof was printed and to give the reasons for it. It is particularly necessary to note the difficulties encountered in the work (in the selection of colors etc) and to indicate how these were overcome, the principal shortcomings and their effect on the quality of the color proof, the corrections that must be introduced in the color schedule upon republication, what changes are best introduced in the colors of the inks, etc.

5. Proofing the color proof. It is necessary to calculate the principal shortcomings of the proof, observed by the technical editor when approving the color proof, both technical as well as with respect to the contents, to analyze their causes, and to indicate possible means of their elimination.

A record should be made of the character of the notes marked on the color proof by the managing editor of the map.

6. Choice of method for effecting the corrections indicated on the color proof. Reasons should be given for the choice of method made by the technical editor for correcting the negatives (positives) and printing forms, and methods should be specified for control of the corrections proposed by the technical editor. The final results of the corrections must also be noted here.

7. It is necessary to record the quality of the forms that were finally corrected or done over and passed on for printing the run.

In addition to keeping the journal, the technical editor should also plot a graph of the work, which may be in any form, but which must contain the dates on which the originals are received, released to production together with other materials; the date on which all prints for proofing the line and background elements were received from the shop and returned to it; the date of the color proof, of its corrections, and of the submittal for approval; the date of the receipt of the approved proof and its transmittal to the shop with indications for the corrections to the negatives (positives) and printing forms; the date of receipt of the combined and quality-control print after correction of the form and of the signature of the forms for their transmittal for the printing run.

Such records have not only an organizational value but also great technological significance for they make it possible to judge correctly the duration and the character of the manufacturing cycle and the correctness of the selected technology.

All the documents and materials transmitted or approved by the technical editor to the shop (technological plans, proof prints, negatives, printing forms, etc) must be signed by him.

CHAPTER 16

TECHNOLOGICAL PROCEDURES FOR THE PREPARATION OF PRINT-
ING FORMS FOR THE PUBLICATION OF VARIOUS TYPES OF MAPS AND ATLASES

The term "publication" means not only the preparation of printing forms and their printing, but all the subsequent operations (binding the atlas or book, pasting the maps on a cloth and mounting them on roller or rods, etc). Since this book considers only portions of the technological process, namely the preparation of the printing forms, we shall restrict ourselves in further analysis of the technological procedures only to this portion of the entire series of works.

As the process of preparation of printing forms progressed, manual processes were first displaced by mechanical ones, and then mechanical processes were displaced by chemical and physical-chemical ones, thereby reducing the time between the preparation of the original of the map and the printing forms for reproduction. Thus, heliogravure replaced manual engraving, lithography replaced heliogravure and was in turn replaced by the offset method. Manual and mechanical methods of applying the drawing in lithography were replaced by photomechanical ones.

In the preparation of negatives or diapositives, the principal processes are the photographic ones, and consequently, we deal with photochemistry in the preparation of line and background printing forms the principal processes are the photo-copying ones, and we deal not only with photochemistry but also with colloidal and physical chemistry.

The nature of all these processes was discussed in the corresponding chapters of the book. These considerations are cited here to corroborate the statement that the modern method of preparation of printing forms in offset cartographic printing, regardless of the actual methods used and of the actual materials used in its realization, is based on photochemical and chemical processes.

This calls for observing certain technological conditions during the time of the performance of all the operations, and for exact technological calculations.

55. Fundamentals of the Technology of Publication of Various Maps and Atlases

Our country publishes in large quantities cartographic products of a great variety of forms classroom wall map, school atlases, handbook and political-administrative maps, general-geographic and special maps for higher teaching institutions, and summary atlases, up to some of the world's largest cartographic works, such as the World Atlas, the Marine Atlas, etc).

Naturally, each of these publications should be different. Even though the technological process of publishing each of these remains fundamentally the same, nevertheless each actual case has to be considered for its own peculiarities in the preparation of the printing form for the publication of a single-sheet or multi-sheet map, classroom map, or handbook map, a single-sheet map, or a multi-signature atlas. In one case a single map is distributed over several sheets, and in the other, to the contrary, several maps are printed on a single signature. As a rule, the

maps are printed on one side, and atlases on both sides, etc. Consequently, a factor that may not be significant for the technology of publication of one map may turn out to be of great importance for others.

The same technological process for the manufacture of printing forms cannot be mechanically applied to all cartographic products and in all cases. The selected technology should correspond to the character of the product. The particular actual technological version must be chosen in such a manner as to insure the highest quality with a minimum consumption of time and means. The tremendous number of various measures, methods, and technological means available in map publication, makes it possible to select a most rational and suitable method for each individual case.

Along with the specific requirements, there are also general requirements, which must be taken into account in the development of the technological plan for publication of a cartographic product. The principal requirements are as follows.

1. The map or atlas should be printed with a minimum possible number of colors. An unjustifiedly large number of colors as a rule reduces the manufacturing profit without producing a map of better quality.

The paper on which the maps are printed is subject to mechanical wear and considerable deformation if an excessive number of colors is used. This is seldom noticed when printing the color proof on the proof press, because as a rule one prints the proof from a dry printing form, while in the regular press the form is wet. The moisture from the printing form is transferred

by the rubber to the paper, which absorbs it. The latter causes the deformation of the paper and reduces its mechanical strength.

The best results would be obtained by printing the map in two colors, i.e., with a single run of the sheet of paper in the machine, but such cases are rare. Multi-colored maps are printed with a considerably larger number of colors. Good results are obtained with cartographic paper having a density of 100 grams per square meter if eight to ten colors are printed. A further increase in the number of colors requires better grade of paper and particularly one of higher density. Thus, when printing in 20 -- 24 colors (school atlases) the paper should have a density of 120 -- 130 g/m², and for more colors 140 -- 150 g/m² are required.

Printing maps with a larger number of colors requires also a considerable improvement in other indices (in addition to density) of paper quality, increasing the cost of the map and it is not always feasible. The greater the number of colors used to print the map, the more difficult it is to insure correct registry of all the elements printed in different colors. Of importance here is not only the paper, but also the operation of the machine register.

2. The selected technological process should consist of elements that are well mastered by the workers and by the engineering-technical workers of the publishing shops. Simple operations, if insufficiently mastered by the workers and by the engineering-technical personnel, may be beyond their capacity, and a well thought-out technology may become unfeasible if its

performance requires a considerable amount of supplementary time and means. There are many such examples in practice.

It is known, that when the silverless methods of preparation of negatives and diapositives were first introduced, the maps were delayed for a long time in production (for example, the sheets for the USSR 1:1,000,000 government map) and turned out to be too expensive. At the present time, when the wash-off relief method has been mastered by the engineering-technical personnel and by the workers, no difficulty is encountered by the NRECh in its use in the publication of many multi-sheet maps for the higher teaching institutions, with sheet measuring up to 90 -- 110 cm and even greater, and a technological process can therefore be worked out with assurance on its basis. Another example is positive copying. Before the copy operators mastered the method of preparation of printing forms by positive copying it was impossible to base the publication technology on this method. As soon as positive copying (specifically from diapositives) was fully mastered by the copy operators it became possible to publish not only individual maps with the positive-copying method, but also large cartographic works such as the publication of the World Atlas at the NRECh in the Minsk and Riga cartographic factories.

3. The technological process for the publication of the map or the atlas must be worked out on the basis of the capabilities of the manufacturing equipment, particularly the reproduction and optical equipment. The correct technological process may turn out to be unfeasible or subject to serious changes if its development does not take into account the capabilities of the existing equipment, and it is known that changing the technological process

during the course of the work affects adversely the schedule and the quality of the publication of maps.

4. The technological process developed should be based on materials at the enterprise, or on such materials that can be readily acquired.

The unity in the modern technological process for publication of different maps and atlases lies not only in the fact that the above general requirements are met, but also in the fact that photomechanical methods are widely used at all the processes.

Thus, the technologist must provide for the following in the development of the technological plan for the publication of maps or atlases:

Wide application of photomechanical processes and elimination of manual ones; printing with a minimum number of colors; the composite elements of the technological process (individual operations) should be well mastered by the engineering-technical personnel and by the workers; allowance must be made for the capabilities of the equipment; the materials used should be available or readily acquirable.

Before proceeding to examine the technological schedules for the publication of individual maps and atlases, let us note several possible ways of streamlining the photo-reproduction operations which are the most important part of the entire technological process of the preparation of printing forms.

It is possible to employ extensively dry silver-bromide photographic plates, prepared at the cartographic factories.

This material is more economical compared with the wet-collodion emulsions, and therefore dry plates should be used in all those cases when the negatives do not serve directly for the publication run (for example, line proofs, different registry prints, etc). The opinion prevalent among many workers that dry silver-bromide plates, particularly those produced in the plant itself, cannot guarantee high quality of printing forms is not at all founded. To the contrary, the practice and the experience of the NRECH shows that in the photography of relatively new non-yellowed originals, which contain sharp outlines and sharp legends, this material can produce negatives and even printing forms of high grade, suitable even for the publication run of maps such as wall-type classroom maps. The only difficulty in the use of dry silver-bromide plates for printing runs is that it is almost impossible to make on the negative any correction necessitated by the changes in the contents of the map, such as are introduced either after the color proof or after the first runs, and particularly in the second editions.

The value and the advantage of dry silver-bromide plates for use as the basic photographic material lies in the fact that they make possible contact duplication of negatives using the following sequence: initial negative -- intermediate dispositive (obtained by contact copying) -- required number of working negatives (obtained by contact copying from the intermediate negative). Another advantage is that they make it possible to obtain diapositives by contact from retouched negatives, i.e., they create the first and most necessary conditions for the transition from negative to positive copying. With this, in particularly complicated

operations where the negatives prepared with dry plates cannot insure the required quality, one can start out with wet-collodion negatives from which working negatives and diapositives are prepared by contact.

Negatives prepared by contact from one intermediate diapositive are more constant in size compared with negatives prepared by projection, and the latter, the same as the quality of the reproduction of the drawing, is of prime importance in map publishing. Incidentally, this circumstance forced us when publishing the World Atlas to adopt for the preparation of the diapositives for all line elements a technology that appeared cumbersome at first glance but which fully justified itself later; this technology can be illustrated by the following sequence: initial wet-collodion negative -- intermediate silver-bromide diapositive -- working silver-bromide negatives -- working diapositives from the retouched negatives. With this, all the negatives and diapositives, except for the initial wet-collodion ones, were prepared by contact.

The use of dry silver-bromide plates uncovers still another technologically very important capability, not feasible with the wet-collodion method. It is possible to obtain so-called composite diapositives.

The composite diapositives is one in which the image is obtained by successively copying from two and even from three negatives that contain different elements. In particular, when publishing the World Atlas, this ability was used to obtain a composite outline of the physical maps, while the hydrography and the relief were drawn on different originals. By drawing these elements on different

originals it was possible to keep the horizontal lines unbroken, something that cannot be accomplished in separation retouching, thus reducing the cost of the retouching because it eliminated such complicated separation as the separation of the hydrography and of the relief.

Ample opportunities for streamlining the photo-reproduction operations lie also in the silverless methods of obtaining negatives and positives. Of all the known methods, the best one is the wash-off relief method. Insuring no less reliable results than dry silver-bromide materials, negatives obtained by the wash-off relief have a very important advantage in map, publishing in that complicated modification of their contents can be made. It was indeed this property of this method that was used in the NRECh when they replaced dry silver-bromide emulsions used previously for contact-manufacture of working negatives of maps for a higher teaching institutions.

Thus, the streamlining of the technological process of the photo-reproduction operations involves extensive utilization of dry silver-bromide plates prepared at the cartographic factories and of silverless methods of negative preparation, including the most reliable one, namely the wash-off relief method.

Practice has shown that in those cases, when it is necessary to obtain four or more negatives for publication of a sheet of a map, it is advisable to prepare by projection only one negative and use intermediate diapositives to obtain the remaining negatives either with dry photographic emulsions or by the wash-off relief method.

The selective coloring method can also give good results, but it has so far not yet been fully worked out.

56. Technological Schemes for the Preparation of Line Printing

Forms of Typical Cartographic Products

Of the variety of maps and atlases produced by the Russian cartographic industry, let us consider the following as typical:

- (1) classroom physical maps;
- (2) classroom historical maps;
- (3) classroom atlases for elementary and secondary schools;
- (4) maps repeating on a sheet;
- (5) topographic maps.

1. Classroom Physical Maps

Like any classroom wall map, a physical map is a visual aid for the teaching of geography in school. It is therefore made with large symbols, insuring relatively easy legibility at a distance of several meters. Usually a classroom physical wall map contains 6 -- 10 levels for dry land and 4 -- 7 levels for the bottom of the sea. The line elements of the contents range from 4 to 6.

The technological process of manufacturing line printing forms for the publication of such a map, used until recently, can be illustrated by the following scheme (Figure 73).

Let us consider the individual operations of the technological process, noting the possibility of improving its efficiency.

Photographic Operations. The fact that the cartographic factories are mastering the process of preparation of dry silver-bromide plates uncovers possibilities for eliminating the wet-collodion method from the publication of such maps. It must be

borne in mind that such maps are frequently republished and it is therefore necessary to insure the possibility of carrying out various corrections on the negatives as well as a sufficiently long life for the negatives. In the wet-collodion emulsion it is possible to make all kinds of corrections on the negatives, but the emulsion does not last long: frequently the film on these negatives begins to peel off even several weeks after their manufacture. Dry silver-bromide materials, to the contrary, last for a long time, but do not afford a possibility of making any substantial corrections on the negatives. Negatives with a sufficiently long life, on which it is possible to make the most extensive corrections, are negatives prepared on silverless chrome-gelatine emulsions, particularly those made by the wash-off relief method.

Taking all this into account, the following process for negative preparation can be proposed.

The original should be photographed on a dry silver-bromide plate, an intermediate diapositive is made from this plate by contact (or by wash-off relief), and the working negatives are made from the intermediate diapositive by contact by the wash-off relief method.

The above scheme may appear at first glance more cumbersome, but this is only a superficial impression for it affords tremendous advantages, consisting of the following:

- (a) Equal dimensions of all negatives for a single sheet of the map provided flat (mirror) glass is used;
- (b) possibility of obtaining (by contratyping) of a high grade image, even from relatively old originals;

(c) the possibility of prolonged storage of negatives for repeated editions;

(d) the possibility of introducing correction in the content of the cartographic picture.

The experience of the NREKCh shows that such a technological scheme, in spite of its apparent clumsiness, is not only more suitable technologically but is also more economical than those previously employed.

For certain classroom wall maps which do not have much line work on them it is possible to prepare in individual cases a single negative for two different elements, provided they are placed on the negative not closer than 7-10 cm from each other.

The retouching operations are carried out in the usual manner. The so-called abbreviated retouching method, recommended by several specialists, cannot be accepted for the following reasons:

(a) it prolongs noticeably the manufacturing cycle, without giving a noticeable economic effect in the case of classroom maps;

(b) it does not make it possible to reproduce rapidly and identically all the line elements in repeat runs or reprints.

The proofing of the correctness of the retouching is carried out by one of the methods discussed above. It must be taken into account here that there is no need for preparing composite proof prints with "red outline" for maps having simple line work. In very many maps it is more advisable to check the correctness of the separation retouching directly on the negatives. By placing

the negative on the retouching stand with the emulsion side downward and by being able in this manner to view it in the natural position and to compare it with the separation dummy, the negative can be corrected on the spot in the presence of the corrector or the technical editor. This method of checking guarantees a high grade of retouching and eliminates unnecessary operations. In many places it is possible to replace the composite "red outline" prints with blueprints on paper, obtained from the retouched negatives. When working on wall maps for elementary and secondary schools, the last method can be considered most efficient.

The printing forms for printing the color proof are made from the corrected negatives in the usual manner.

If positive copying is used rather than negative copying, the technological scheme changes considerably. Positive copying is essential in the publication of wall classroom maps in that case, when these maps are printed in large runs (50,000 copies and more). In those cases when the maps must be printed in small runs (15-35,000 copies), positive copying is not advisable for it increases the cost of the map considerably. One cannot assume that the same positives can be used to publish a map for many years for every new edition frequently calls for changes in the contents of the classroom maps, thus requiring reworking the diapositives. In positive copying, along with employing dry silver-bromide photographic plates or silverless methods for the preparation of negatives and positives for line printing forms, it is possible to use a technological scheme in one of the following versions:

(1) Initial negative photographed through a prism -- intermediate diapositive -- working negative -- separation retouching -- working diapositive -- printing forms;

(2) initial negative -- working negatives obtained by contact copying using the selective-coloring method -- separation retouching -- working diapositives -- printing forms.

Comparing these schemes, we see that the first contains an additional intermediate diapositive, which is not included in the second scheme. The first scheme appears therefore to be less efficient.

Actually this scheme, to the contrary, is more suitable for manufacture. When working with this scheme it is possible to use for the preparation of the negatives and diapositives the wash-off relief method, which is considerably simpler and more reliable than the selective-coloring method. Experience has shown that the seemingly longer first technological scheme is more suitable both with respect to time and with respect to economy.

In many classroom maps it is possible to eliminate composite copying if certain legends (hydrography, different indices, etc) printed in the same color as the line elements (contours, roads, etc) are pasted on not on the lettering original but on the line original. This is difficult to attain on physical maps, but on political and other special maps this is fully attainable and should not cause any particular difficulties.

2. Classroom Historical Maps

The scheme for preparing negatives or diapositives for this group of maps differs little in principle from the scheme considered

above. One can clearly see in this case the possibility of simplifying the process in one of the following two manners:

(1) Preparing one negative for two or even three content elements.

(2) Eliminating the composite copying by placing the legends, that are printed in the same colors as the contour elements, on the line original.

To employ the first and second methods the technical editor must participate in the work on the map long before it is submitted for publication. It is particularly important that the technical editor participate in the development of the technological design of the map.

As a rule, before a classroom historical map is prepared, there is on hand an approved and completed author's original, showing not only the background but also the line material in the final publication colors. Since the map is made from a single original, it is not mandatory that the technical editor participate in this process. The technical editor should participate in the design of the map. The presence of an approved author's original simplifies his task.

A single negative can be made to serve for two or several elements either by covering the unnecessary elements during the copying, if the different elements are far from each other, or else by blacking out part of the negative before copying. In the latter case an asphalt lacquer is used before copying on a negative containing several elements to cover all the unnecessary elements leaving uncovered on the form only the elements which

are to be reproduced by the form that is being copied. An asphalt lacquer, diluted in benzine, does not dissolve the upper protective coating on the negative and therefore cannot do any harm. This circumstance makes it possible to place a layer of asphalt lacquer on the surface of the negative and then to remove the layer so that the same negative can be used for copying several elements.

Such a procedure can be used effectively on historical and certain other special classroom maps. It is important that the covering with asphalt lacquer be carried out under the control of the technical editor. The technique of performing this operation is quite simple. It is merely necessary to insure that the asphalt lacquer covers the negative in a thin layer, insuring at the same time a sufficient optical density in places of the covered drawing.

Placing the legends on the line original, in addition to having purely editorial advantages, has also the advantage that the legends can be pasted on in a most suitable manner relative to the contour. The main objections to this procedure are usually that the paste-ons cover up some of the contour lines and that placing different legends on different originals affects adversely their mutual placement. Experience has shown that in most cases it is possible to avoid covering-up the contours by the paste-ons on classroom historical maps. If this is unavoidable, it is best to redraw the contours through the paste-ons on the line original, rather than dispense with this method entirely. The participation of the technical editor in the solution of this problem leads to an effective solution in each actual case.

3. Classroom Atlases

It is essential that the technical editor participate in the production of atlases from the very beginning, more so than in the production of other works. Whereas in the production of any map, the technical editor is merely required, after the editorial preparation is complete, to compile jointly with the managing editor the technological plan for the publication and to assist in the further development of the technology, in the case of an atlas the technical editor must participate in the editorial-preparatory work from the very beginning.

The first stage in the editorial-preparatory work is the preparation of the dummy for the make-up of the atlas, which is difficult to compile without participation on the part of the technical editor. It is necessary to have from the very first beginning an idea not only of the methods used to publish the planned atlas, but of many other details, such as the construction of the binding, the method of sewing the signatures, etc. The development of the make-up dummy depends much on the solution of such problems as the choice of paper on which the atlas is to be printed. The format of the paper determines to a considerable extent the format of the atlas, and the quality of the paper determines whether the atlas should be printed on one or both sides of the paper. We can see that many a fundamental and important problem in publication requires a solution (and a final one at that) even at the editorial-preparatory stage of the work. Naturally, these problems can be solved correctly only if the managing and technical editors of the atlas engage in those problems jointly.

Of primary importance in the development of the make-up dummy of the atlas is the calculation of the format of the printed sheet, starting with "cleaning" the sheet before printing and ending with trimming the finished block of the atlas. If we assume that in "cleaning" the sheet is trimmed on each side by 1 cm, and in the trimming of the finished block of the atlas from the forward, upper, and lower sides it is trimmed by 0.5 cm and that 2 cm are left for the "gripper," the format of the paper sheet (Figure 74) can be calculated from the following equations

$$A = \frac{x_a}{2} + \frac{x_n}{2} + \frac{x_u}{2} + 60 \text{ mm};$$

$$B = \frac{x_b}{2} + x_f + 40 \text{ mm},$$

where x is the number of maps placed on a single signature, if the maps are arranged symmetrically; a or b are the dimensions of the sides of the map (as shown on the drawing), u the upper margin, l the lower margin, and f the forward margin.

Using another arrangement, also symmetrical, of the maps on the signatures, the equations can assume the form

$$A = \frac{x_b}{2} + x_f + 60 \text{ mm};$$

$$B = \frac{x_a}{2} + \frac{x_n}{2} + \frac{x_u}{2} + 40 \text{ mm};$$

Figure 74 shows the arrangement on a printing sheet of the turn-about two-page maps, for which the calculations are to be made. If single-page maps are arranged, they should be placed in such a way that the dimensions of each pair (according to the drawing), including the distance between them, agree with the dimensions of the two-page turn-about maps.

If the maps are not placed symmetrically, a very rare occurrence, it is impossible to employ any general equations and the format of the signature must be determined by placing on it the dummies of the individual maps.

When solving these problems it is necessary to be guided in all cases by the standard formats of paper. It is necessary to calculate with particular care the format relative to the width of the paper sheet, for this indeed is limited by the paper-producing machine. The standard dimensions used up to the present are (width) 62, 72, 84, and 93 cm.

Since every atlas, including a school atlas, has as a rule two-page turn-about maps as well as single-page ones, the calculation of the front and back margins is very much influenced by the method in which the signatures are assembled and the blocks are sewn, on which the character and the size of the back of the binding depends. Without considering this problem in detail here, let us note only that if all the factors are not accounted for sufficiently at the very start of the work (in the development of the make-up dummy), the preparation of the printing form may turn out to be very complicated and may affect the quality of the atlas.

The technical editor must pay particular attention to the technology of the design of the atlas. In school atlases, which are constantly reprinted, it is necessary to design where possible on the basis of whole printing sheets so as to simplify the work when reprinting. It is best to carry out the separation retouching of the negatives rather than risk poor registry of the elements in

printing. It is normal to employ two line originals, one line original on which all the line elements are drawn, and one containing all the legends.

In school atlases, as in school maps, it is best to place on the line original those legends that are printed with the same color as any one line element of the contour.

In those cases when the atlas is designed on the basis of individual maps, the montage of the maps on the printed sheet becomes difficult. The arrangement of the maps becomes complicated owing to cumbersome montage of different originals (line, wash off relief), each of which must be mounted with a maximum tolerance of $\pm 0.1-0.2$ mm in position. The existing methods of montage of originals cannot insure such accuracy in most cases.

Since it is necessary to deal in publication, for various reasons, not with whole printed sheets but with individual maps of the atlas, let us consider briefly the methods used in their montage on the printed sheet.

It is first necessary to prepare a base for the montage. The base can be a sheet of plywood, with a white paper glued on it. Using one of the accurate methods (best of all a "coordinatograph"), the corners of the internal frames of the maps mounted on the sheet are drawn. When calculating the positions of the corners of the frames it is absolutely essential to take into account not only the data indicated above for the format of the paper sheets, but also the distances from the internal frames to the edge of the drawing. With this, it is necessary to take into account only those maps, in which these distances are maximum.

The "gripper" line, from which all the points are measured, is drawn on the base that is prepared for the montage.

To obtain the corners of the internal frames that are closest to the valve line one measures a section equal to 20 mm (gripper) + 5 mm ("cleaning" of the block) plus the value of the lower (or forward) margin plus the distance from the edge of the drawing to the inner frame (this may be different in different atlases). The next corners are obtained by measuring the values equal to the dimensions of the inner frame of the map. A section is then measured from these points equal to twice the distance between the inner frame and the edge of the drawing plus the value of the upper margin plus the value of the lower margin plus 10 mm ("clearing" for two blocks). The last corner line of the inner frames (for the case illustrated in Figure 74) is obtained by laying off a section equal to the dimension of the inner frame.

To obtain the first corners of the inner frame, a section is measured from the side perpendicular to the gripper, equal to the forward margin plus the distance between the edge of the drawing and the inner frame plus 5 mm ("cleaning" of the block). Next, by laying off a section equal to the value of the inner frame, one obtains the subsequent corners. Following this, after laying off a section equal to twice the distance from the edge of the drawing to the inner frame plus twice the forward field plus 10 mm ("cleaning" of two blocks), the next corners are obtained, and finally, by laying off a section equal to the size of the inner frame, one obtains the last corner.

Usually the corners of the frame are joined with lines which extend beyond the boundaries of the maps. On the originals, the

corners of the inner frames are also joined with lines which are carried to the edges of the originals. From the coincidence of these lines on the originals it is possible to control to some extent the accuracy of the montage. The best way to attach the originals to the base is with small nails, which must be bent backwards.

The first to be usually mounted are the line originals, and then the originals of the legends are mounted on the line originals, and then the sheet is photographed. Consequently, the first to be made is a negative of the legends.

The legend originals, as indicated, are mounted above the line originals. For this purpose small holes are made in the legend originals at the corners of the internal frames and in several places where the geographic grid intersect. By aligning the equally-marked strokes on the legend and on the line originals (through the drilled small holes), the originals are lined up, and the legend originals, like the line originals, are secured to the base with small nails.

After the legend originals are photographed, they are removed from the montage and the line originals remaining on the base are photographed.

The wash-off relief originals can be mounted the same as the legend originals, although in practice they are usually photographed one by one and the printed forms are prepared by composite copying.

In spite of the fact that the method used above of mounting the individual maps of the atlas on the printed sheet is quite

primitive, it comes closer than all known methods to meeting the requirements imposed on this process, in the absence of non-deforming photographic materials on an elastic base. If such materials are available it becomes possible to employ more accurate and better methods for the mounting of dispositive and negatives.

In the preparation of printing forms for the publication of atlases it is advisable, more than in any other case, to prepare duplicates of the negatives by contact. Here the accuracy of the dimensions and the possibility of obtaining high grade reproduction fully justify the somewhat longer process of photo-reproduction work. It is very convenient to employ the wash-off relief method which, while not inferior in quality to that employing dry-silver-bromide materials, permits corrections in the contents of the map to be made on the negatives, a very important factor when reprints are made.

The negatives are retouched in the usual manner. To proof the retouching in the preparation of the printing form for a school atlas it is necessary to employ prints combined "in the red outline," and prints made "in their own colors." If many errors were made on the negative during retouching it is necessary to employ paper blueprints made from the corrected negatives to check how correctly and how completely the corrections agree with the notes of the technical editor.

The forms are copied from the retouched and corrected negatives in the usual manner on chrome-albumin emulsions.

Thus, the process of preparing line printing forms for the publication of a school atlas can be illustrated by the scheme given in Figure 75.

4. Maps Repeating on a Sheet

To duplicate the same map on a printing sheet several times, one of the following methods is used at the moment:

(a) Duplicating the map on the printing form by copying in a copying-duplicating machine. With some skill on the part of the operator, this method insures high accuracy of alignment of the individual elements with each other, provided the dimensions of the negatives, on which they are made, are sufficiently close. This method, however, has serious shortcomings, preventing its widespread application in manufacture: first, it is difficult to obtain identical negative dimensions; second, to duplicate an image in a duplicating-copying machine it is necessary to increase the exposure time excessively, thereby deteriorating the quality of the forms owing to dark hardening and other phenomena occurring in chrome-albumin emulsions; finally, third, this method of duplicating the image on the printing form essentially eliminates the possibility of carrying out positive copying.

(b) Duplication of the originals and their montage in the same manner as used in the publication of the atlases. The placement of the original usually reduces to photographing the initial original from the negative on photographic paper pasted on a rigid base, and printing a copy of the original, which are then mounted on the prepared base, thus obtaining a composite original. This method is free of certain shortcomings inherent in the method of duplicating the image in the copying machine but nevertheless it does not solve satisfactorily the problem, for in all cases the quality of the drawing is noticeably deteriorated.

(c) Less frequently employed is the method of duplicating the image by sequential and composite copying (in "phantom outline" etc) in ordinary copying frames. This method, for all its shortcomings, which are inherent in the method of duplicating an image in duplicating-copying machines, is considerably inferior to the latter in accuracy of alignment of the elements.

As can be seen, none of the three methods most frequently used to duplicate maps which repeat on the same printing sheet can be satisfactory, for each has serious shortcomings. More rational is the method proposed below, the nature of which is as follows.

The publication originals, which are to be repeated on the printing sheet, are photographed once in their final published size (if several such maps are published, they are first mounted in an common composite original). A positive is prepared from the negative, and then the image is duplicated by multiple copying of the initial negative on the same positive, obtaining thus a complete composite sheet. The necessary number of working negatives is obtained from the resultant common positive by contact printing, and the process is then continued in the usual manner. Let us illustrate the described method with an example. Assume that we want to obtain printing forms of a sheet, on which are located three maps, each repeated three times (Figure 76). The letters A, B, C on the drawings designate different maps, each of which should be repeated on the form three times (shown in dotted lines).

The originals are mounted in a column (I), and the montage

is then photographed and copied three times on the same silver-bromide plate (I, II, III), thus obtaining a composite positive, in which each of the three maps is repeated three times. The next step is to prepare working negatives by contact means and to perform all the subsequent operations in the usual sequence. The above procedure can be illustrated by the following scheme (Figure 77). The same method of repeating maps on a sheet was checked many times with a great variety of objects (inserts in textbooks, maps for the Great Soviet Encyclopedia and many others), and invariably gave good results. It is free both of shortcomings that are peculiar to the duplication method using copying-duplicating machines, as well as of the shortcomings that are peculiar to the method of duplication of images by duplicating the originals. It makes it possible to employ equally well both negative and positive copying methods. The method described can be used with dry silver-bromide plates.

5. Topographic Maps

In the preparation of the printing forms for topographic maps one can encounter the following cases: (1) one map is published on a single printing sheet, (2) several maps are published on a printing sheet. In the former case there can occur no particular difficulties. The second case, which is encountered considerably more frequently, is of great practical interest.

To prepare composite negatives in the publication of several maps on a single printing sheet many technological schemes were proposed, based on the use of a great variety of materials as

the base (glass, photographic film, viniproz, astralon etc).

By way of example let us show two such schemes (Figures 78 and 79), which show at a glance the different approach to the preparation of the composite printing forms for the publication of several topographic maps on a printed sheet.

The first scheme, widely used in manufacture, is unsuitable because it is based on the use of photo-technical film, which, as is known, is subject to considerable linear deformations, therefore not providing the necessary accuracy of alignment when printing different elements. The second scheme also has serious shortcomings. The composite printing forms are obtained by multiple combined copying, which provide neither the required accuracy of alignment of the different elements, nor a high quality image. A serious shortcoming of the second scheme is the fact that it is even less capable of giving reproducible results upon repeated editions of any forms than the first one.

A sufficiently simple and convenient solution to this problem would be to mount the original on a printing sheet placed on the photo-camera copying screen. However, for several reasons, this is possible only in exceptional cases. Therefore, in the majority cases the composite printing forms are obtained by photo-mechanical methods.

When using dry silver bromide plates, this problem can be solved relatively simply and the following technological scheme may be employed. The originals (two or four) are photographed and wet-collodion negatives are prepared. A composite positive is made on a silver-bromide plate by contact from all the negatives

of the map that are printed on a single sheet, and the necessary number of working negatives are prepared from this positive by contact. This is followed by separation retouching of the negatives and all the further processes (Figure 80).

From the point of view of the technical execution, the technological scheme is even simpler if viniproz or similar little-deforming transparent plastic material coated with silver bromide is used. The initial wet-collodion negatives are used to make by contact printing positives which are mounted on glass into a composite positive. From the latter, the working negatives are prepared by contact, and the process then follows the usual sequence.

If it is impossible to use silver-bromide materials, the positives can be made on viniproz by the wash-off relief method with further montage of the positives, preparation of working negatives in the same manner, etc (Figure 81).

57. Special Features in the Preparation of the Background Printing Forms

In the preparation of the line printing forms the technical editor is capable to select only the technological methods, without establishing their number, for the latter is already predetermined; but in the preparation of the background printing forms the technical editor establishes not only the technological methods, but also the number of inks for printing a given map (or atlas).

The number of inks with which the map is published has an economic and technical significance. It is economically important.

to use a small number of inks, for this makes the cost of printing the run less and accelerates the manufacturing cycle. It is technically convenient to use fewer inks, for this reduces the effect of deformation of the paper, makes it possible to print larger runs, etc. Consequently, the technical editor should attempt to print the map with the least number of inks needed for good reproduction of its color design. Of great importance in this matter is the ability of the technical editor to operate correctly with combinations of inks and with screens.

Screens can be used over a very wide range. The usually employed 30, 50, and 70% screens can be considered the minimum assortment. Experience in work with such complicated products as the World Atlas has shown that clever utilization of screens makes it possible, by using a single ink and a not too dark one at that, to obtain four or five readily distinguishable steps. Even more can be done by extensive variation of various screens for all possible combinations of different colors.

To obtain reproducible results it is necessary to measure the screens that are used for the preparation of the background printing forms. For this purpose it is necessary to employ the procedure developed by the TsNIIGAIK and to use toolmaker's optical microscopes of the MIR-12 type. Errors in the measurement of the percentage relationship of transparent and opaque elements in the screen, as shown by experience at the NRECh, must not exceed 5%. The above-mentioned measuring microscopes are accurate enough for the purpose. It is necessary to measure each negative (or positive) of the screen before it is passed on to copying.

Determination of the percentage ratio of the transparent and opaque elements of the negative (or positive) of a linear screen is quite simple and requires no particular explanations. Certain complications arise in the determination of the percentage ratio of the printing and blank elements in dot and cross screens, introduced into the forms.

The percentage ratio of the areas of the printing and blank elements of the printing form on a crossed screen can be calculated from the following equation (Figure 82).

$$C = \frac{10000 - O_1 O_2}{100},$$

where C is the percentage of printing elements over the entire area, taken to be 100, O_1 and O_2 are the percent opaque elements of two screens that are crossed in copying. By way of illustration, let us consider the following example. Assume that we have marked on some area a crossed screen by crossing 70% and a 50% screens (The percentages indicate the percent transparent elements on negatives and the percent opaque and printing elements on the positives and on the forms). On the printing form, the percentage of the printing elements as a ratio is

$$C = \frac{10,000 - 30 \times 50}{100} = \frac{10,000 - 1,500}{100} = \frac{8,500}{100} = 85\%$$

If 20 and 40% screens are crossed, the printing elements on the printing form would amount to

$$C = \frac{10,000 - 80 \times 60}{100} = \frac{10,000 - 4,800}{100} = \frac{5,200}{100} = 52\%$$

The dot screens must be introduced on the form from a specially-prepared negative (or positive). In this case, the

percentage content of the transparent and opaque elements on the negative can be calculated from the equation given above, in which O_1 and O_2 are taken to be the percentages of the opaque elements on the negatives of the line screen, from which the special negatives were prepared for introducing the dot screen on the forms.

In positive copying, the size of the printing elements corresponds to the size of the opaque elements on the positives of the screens. The equation for calculating the percentage of the printing elements relative to the total area therefore becomes

$$C = \frac{10,000 - T_1 T_2}{100}$$

where T_1 and T_2 are the percentages of the transparent elements on the first and second screens.

An exact determination of the percentage ratio of the printing and blank elements on the printing form is of great practical importance for regulation of the strength of the tone of the ink, which is particularly important when a combination of a small number of inks is required to reproduce a wide range of colors and hues, as is frequently encountered in the publication of various special maps.

Operating experience shows that by combining inks it is possible to operate with five gradation transitions of screens, and that with inks that are not included in the combination it is possible to obtain four readily-distinguishable steps, using the following screens: 15% dot, 40% line, 70% cross, and solid tone.

S. F. Sadchikov of the TsNIIGAIK developed in 1953 a technology and a procedure for preparing background printing forms for printing multi-colored maps with merely three or four background inks. He also worked out a procedure for the preparation of high-grade negatives of screens, as well as methods for measuring the screens. Tests made in production on the procedure and technology, proposed by S. F. Sadchikov, including the printing of a run of one of the most complicated maps for publication, namely the 1:30,000,000 political World Map, has shown not only that it is possible to employ this method extensively but that it also has advantages from the manufacturing point of view.

The procedures and techniques used to obtain negatives of screens with exact observance of the percentage ratio of the transparent and opaque elements call for making a negative from the original line screen, using a photo-reproduction camera (by projection) without an objective. It is proposed that only the 30% and 50% screens be photographed by projection, and the others be made by contact.

The technology used at the TsNIIGAIK to reproduce the background color of a multi-colored map is based on the fact that almost all the shades used on the map can be reproduced by three specially-chosen inks. In individual cases it is possible to add a fourth color to the basic three, this being necessary to reproduce an already prepared color design of a map. Thus, it is based on the use of a maximum of four inks for the background coloring of the map.

The group of inks employed for this purpose consists of rose No 232, yellow No 589, and blue consisting of a 1:1 mixture of Nos 364 and 365. The fourth color used in most maps is the best green No 434. Another color (brown or other) can also be used.

The chart of color combinations, prepared by S. F. Sadchikov at the TsNIIGAIK, printed with the basic group of three colors and supplemented with green ink, shows five gradation transitions for each color: 100, 70, 50, 30, and 50% of the color tone, it being recommended that the 70, 50, and 30% tones be prepared by using line screens on the form, and the 15% by dots, and the 100% by solid color.

The working procedure and the inks themselves, proposed by the TsNIIGAIK for map publishing, can be considered to be universal. However, other charts can also be prepared at various enterprises, serving to solve more limited and particular problems. The NRECh has produced, in addition to the TsNIIGAIK color chart also a color chart including combinations which can produce eight colors in the case of double and triple overlaps. With this, a scale consisting of four gradation transitions, 12, 30, 58% (crossed, composed of 30 and 40% line screens), and 100% (solid) is used for the printing of each ink. This color chart is also helpful in work.

Part IV

FORMULAS FOR WORKING COMPOUNDS

CHAPTER 17

RECOMMENDED WORKING SOLUTIONS AND COMPOUNDS AND PROCEDURE
FOR THEIR PREPARATION58. General Requirements Concerning the Preparation of Working
Solutions and Compounds

Map-publishing processes are primarily physical-chemical processes. In carrying out all the manufacturing operations, from the photography of the original to the printing of the run, the publishers of the maps must employ, in final analysis, the results of most complicated physical-chemical transformations, the correct course of which affects the result of the work. Of primary significance is the normal operation of all the compounds and working solutions used in the different manufacturing operations. The accuracy and care with which these materials are compounded exerts a decisive influence on the course and on the result of the publication of the map or atlas.

In spite of the fact that each working compound employed is specific and requires a definite state and definite conditions of preparation, there are also general requirements concerning the composition of working solutions and compounds which if violated always lead to failure. The general requirements are as follows:

1. Only chemically-pure chemicals can be used for the preparation of working solutions and compounds. The use of commercial chemicals is not permissible, with the exception of those limited cases, when this is specially approved in the formula.

Even the slightest contamination of reagents by extraneous substances may affect substantially the course of the chemical reaction and spoil the results of perhaps a very great amount of labor-consuming preceding work. The most reliable and reproducible results are obtained with so-called analytically-pure (ch.d.a.) chemicals. In many cases it is enough to employ pure chemicals (ch). In any case one can employ materials the chemical purity of which is not less than specified by the corresponding GOST (or OST) standard and with these the materials can be replaced only by purer ones (commercial ones by pure or pure by analytically-pure, but in no case in the reverse order). Thus, the first and obligatory condition in the compilation of working solutions and compounds is strict observance of the chemical purity of the chemicals employed. With this it is necessary to take into account that certain chemicals may lose their quality or may become entirely unsuitable owing to prolonged or inaccurate storage or storage in unsuitable conditions (temperature and humidity of air, vessels, kind of stopper, conditions of illumination, etc).

2. Strict observance of the conditions under which each compound is prepared, particularly the temperature, otherwise failure in work may result. For normal operation of the ready-mixed compounds, and also for their safe preparation (for example, when diluting sulphuric acid with water), it is essential to observe the sequence in which the solutions are dissolved and mixed. The sequence of the operations must follow strictly the one indicated in the procedure for the preparation of each solution. This is particularly important in large-scale work, when the maximum reproducibility of the results is required.

3. All the compounds must be prepared and stored in suitable vessels, which must not react at all with the contents. The vessels used for the preparation of all the solutions should be reliably clean. It is best to employ the same vessels for the same compounds. The fact that most solutions are prepared and kept in glass vessels facilitates the problem, for glass is one of the materials which is easily cleaned. It is necessary to wash and clean the vessels carefully, to remove dirt not only from the inside but also from the outside. Even in those cases when a vessel is always used for the same compounds it should be thoroughly washed before each filling. It must be understood that dirty vessels, used for the compounding or storage of working solutions and compounds, is frequently the cause of failures in work and of spoilage of materials.

4. Of great importance are conditions under which the chemicals and ready compounds are stored. It is necessary to take into account the fact that certain compounds are sensitive to light and therefore cannot be stored in transparent vessels in bright rooms (this includes, for example, iron-salt compounds for copying etc). Some compounds require hermetic sealing (for example, calcium chloride, its solutions, and others), and there are compounds (for example photographic emulsions in the form of jellies) which must be stored at a fixed temperature; finally, there are compounds which cannot be stored close to each other. The latter, incidentally, is also of great importance in the prevention of fire. With this, control over the storage of chemicals and finished compounds must be exercised not only in the warehouses but also in the shops and laboratories.

59. Compounds Used in Photographic Processes

Solutions to Remove the Emulsions from Negatives and to Prepare Glass.

Silver-bromide negatives are immersed in warm water. Within two to three hours the emulsion swells enough so that it can be readily scraped off the glass. In wet-collodion methods the emulsion can be softened in water at room temperature. After removing the emulsion the glass is cleaned with one of the following solutions.

1. 40% nitric acid, if the cleaning of the glass is carried out in a special bath.

If there is no such bath, the glass is cleaned with the following solution:

Potassium bichromate	15 grams
Sulphuric acid (specific gravity 1.84)	200 ml
Water	1,500 ml

The potassium bichromate is dissolved in hot water (70-80° C). The solution is cooled and the sulphuric acid is added in a thin stream with constant stirring. When adding the acid to the solution of the potassium bichromate it is necessary to see to it that the resultant mixture does not become heated to above 50-60°. The solution can be prepared using rubber gloves only. The eyes should be protected with protective goggles.

Before preparing a wet-collodion or dry silver-bromide plate, the glass is again cleaned with one of the following solutions:

1. Raw (or denatured) alcohol 1,000 ml
- 10% iodine solution in alcohol 2-3 ml

The iodine solution is poured into the prepared amount of alcohol.

2. Raw (or denatured) alcohol	1,000 ml
Nitric acid (specific gravity 1.4)	0.5 ml

The acid is poured into the measured amount of alcohol.

Solutions for the Wet-Colloid Method of Preparing Negatives

Colloid from Colloxylin

Colloxylin	40 grams
Rectified ethyl alcohol	480 ml
Sulphuric ethyl ether	480 ml

The colloxylin is placed in a mixture of alcohol and ether and left in it until it is fully dissolved. The ready solution should be kept for not less than 1-2 days.

Colloid Made of Celluloid Film

Nitrocellulose film, with emulsion removed and cleaned	100 grams
Rectified ethyl alcohol	2,000 ml
Sulphuric ethyl ether	2,000 ml

The specific weight of the finished solution should be 0.784.

The celluloid film (motion picture film, sound-recording tape, or similar) is rid of the emulsion layer and washed in hot water (80-90° C). The film with the emulsion removed and thoroughly washed is dried, cut into small pieces, and dissolved in a mixture of equal parts of alcohol and ether with constant stirring. After the dissolution is complete, the colloid should remain standing for 3-4 days. It is best to dissolve the film in a flask with a wide throat.

Solution for Iodinizing the Collodion for Line Work

Rectified ethyl alcohol	1,000 ml
Cadmium iodide	80 g
Ammonium iodide	45 g
Calcium chloride crystalline	15 g

The above salts are added to the alcohol and dissolved in the indicated sequence. Each salt is added to the solution after the previous one has been completely dissolved. After all salts have been completely dissolved, the solution must be filtered through filter paper. To prevent evaporation of the alcohol, the funnel used to filter must be covered with a clean glass plate.

Solution for Iodinizing Collodion for Halftone Work

Rectified ethyl alcohol	750 ml
Potassium iodide	8 g
Cadmium bromide	10 g
Ammonium bromide	5 g
Distilled water	10-12 ml

The potassium iodide and the cadmium bromide are dissolved in alcohol in the above sequence. The ammonium bromide is dissolved separately in the amount of distilled water indicated in the formula. The solution of ammonium bromide is then poured in to the alcohol solution of the potassium iodide and cadmium bromide. The finished solution must be filtered.

Iodinized Collodion for Line Work

Collodion from colloxylin (or celluloid film)	1,000 ml
Iodine compound for line work	100 ml

The collodion must be filtered through cotton. The iodinating solution is poured into the filtered collodion. Before using, the iodinated collodion must be left to stand for 2-3 days, at any rate not less than 24 hours.

Iodinated Collodion for Halftone Work

Collodion from colloxylin (or celluloid film)	2,250 ml
Iodine compound for halftone work	750 ml

The collodion is filtered through cotton, after which the iodine compound is poured into it. Collodion for halftone work retains its properties for a short time (for only 1-2 days), after which its contrast increases and it acts like line-work collodion. Therefore the collodion must not be prepared for halftone work more than 1-2 days before work. Before using, the collodion must be left to stand for not less than 12 hours.

Solution for Covering the Edges of Glass Before Coating it With Collodion

Aviation benzine	1,000 ml
Natural rubber (non-vulcanized)	10 grams

The rubber is cut into small pieces and placed in benzine until it is fully dissolved (2-3 days), after which the solution is filtered through gauze.

Solution for Sensitizing Collodion Plates Before Photography

Silver nitrate	100 grams
Distilled water	1,000 ml
Nitric acid (specific gravity 1.4)	20 drops

The silver nitrate is dissolved in the distilled water and filtered through cotton. The nitric acid is added to the filtered solution drop by drop.

Developer for Line Wet-Collodion Negatives

Ferrous sulfate	500 g
Copper sulfate	250 g
Gelatine (10% solution)	300 ml
Sulphuric acid (specific gravity 1.84)	30 ml
Water	15,000 ml

The ferrous sulfate and the copper sulfate are first dissolved in small amounts of warm water (40-50° C). The solutions are mixed and filtered through cotton. The gelatine is dissolved separately in warm water and the solution is poured into the warm solution of the sulfate salts. The gelatine solution must be added to the sulfate-salt solutions with constant stirring so that the solutions become thoroughly mixed and so that the gelatine does not coagulate. After the solution is cooled, it is brought to the required volume by adding the water. The acid is added last.

In the formula given above the gelatine is introduced to make the surface energy of the photographic emulsion and of the developing solution nearly equal, thus contributing to a more uniform distribution of the emulsion over the surface. Instead of gelatine it is possible to introduce for this purpose alcohol (rectified, denatured, or raw). The developer must then be compounded in accordance with the following formula:

Ferrous sulfate	500 grams
Copper sulfate	250 grams

Alcohol	600 ml
Sulphuric acid (specific gravity 1.84)	30 ml
Water	15,000 ml

The sequence of mixing is as above, except that the alcohol is added instead of the gelatine solution.

Developer for Halftone Wet-Collodion Negatives

Ferrous sulfate	400 grams
Glacial acetic acid	300 ml
Alcohol	300 ml
Water	10,000 ml

The ferrous sulfate is first dissolved in warm water, after which the acetic acid and the alcohol are added in sequence. The finished solution should be filtered through four thicknesses of cotton or gauze.

Solution for Intensification (Bleaching) of Wet-Collodion Negatives (Intensifier)

Copper sulfate	700 grams
Potassium bromide	300 grams
Water	10,000 ml

The copper sulfate and potassium bromide are dissolved each individually in warm water, after which the two solutions are mixed together, and water is added if necessary. The finished solution must be filtered through cotton or through four thicknesses of gauze.

If the bleaching is not on a rack but in a tray, it is necessary to employ a somewhat less economical intensifier, but one

producing better results and made up in accordance with the following formula:

Copper sulfate	100 grams
Potassium bromide	400 grams
Water	1,000 ml

The sequence used in mixing the solution is the same as above.

Silver Nitrate Solution for Blackening Wet-Collodion Negatives

Silver nitrate	50 grams
Water	1,000 ml

Usually the negatives are not blackened in a special solution of silver nitrate but in an exhausted sensitizing solution for wet-collodion plates, the concentration of which is brought up to 5%.

Solution for Reducing Wet-Collodion Negatives

(Farmer's Reducer)

The reducer can consist of two solutions that are mixed together immediately before using.

First solution: Hypo	100 grams
Water	1,000 ml

Second solution: Potassium ferricyanide	10 grams
Water	1,000 ml

The first and second solutions are mixed separately, with the hyposulphite being dissolved in hot water, and the two solutions are mixed directly before using in a 1:1 ratio.

Fixing Solution for Wet-Collodion Negatives

Crystalline hypo	400 grams
Water	1,000 ml

The hypo is dissolved in hot water and after the solution cools down it is filtered through four layers of gauze or some other loose cloth. When using the anhydrous hypo its amount for the same volume of water must be reduced by 1.5 times.

A large number of great variety of formulas are available for protective coatings for negatives, depending on the materials used for the purpose.

Protective Lacquer of Hydrolized Gelatine

Hydrolized gelatine	1,000 ml
Glycerine	10-15 ml
Water to make the specific gravity of the solution	1.03

300 grams of gelatine are placed in 500 ml of water and left there to swell for several hours. The swelled negative is melted in a water bath, 70 ml of glacial acetic acid is added, and the mixture is boiled for several (2-3) hours. An indication of the hydrolysis of the gelatine are the flakes that settle out of the solution. The boiling is stopped and after the solution is cooled it is filtered through a gauze that is folded into four layers or through some other loose cloth. Water is added until the specific gravity of the solution is 1.03. The glycerine is then added.

Before using the lacquer it is necessary to check the following: the temperature of the gelatine must not be above 15-17° C. If a check shows that the lacquer jellied at a higher temperature, it cannot be used as a protective coating. It is necessary to prepare the lacquer again, increasing the time of boiling of the gelatine solution. The finished lacquer should be transparent.

**Solutions and Compounds for the Preparation of Negatives
on Dry Silver-Bromide Plates and Films**

Glue For Tacking the Phototechnical Film to the Glass

Commercial gelatine	45 grams
Commercial glycerine	80 ml
Water	500 ml

The gelatine is soaked in water at room temperature and it is allowed to swell for 1-2 hours. The swelled gelatine is molten in a water bath at a temperature of 50-60° C and glycerine is added to the resultant solution. The glue is smeared on the glass and every time before the photography a phototechnical emulsion is tacked to it with the side without the emulsion. The glue-coated glass is suitable for use for 8-10 days.

In practice it is necessary to use in many cases special developers for the development of various negatives. There are therefore many formulas of various developers. We give below formulas of developers that give good results.

Universal Metol-Hydroquinone Developer (Chibisov's)

Metol	1 gram
Hydroquinone	5 grams
Sodium sulphite anhydrous	26 grams
Sodium carbonate anhydrous	20 grams
Potassium bromide	1 gram
Water	1,000 ml

Each of the above chemicals is dissolved separately in warm water (35-40° C), after which the solutions are mixed in the following sequence: the metol solution with the sulphite solution, after which

the solution of hydroquinone is added, followed by the solution of the sodium carbonate, and finally by the solution of potassium bromide. The above sequence of mixing the solutions must be strictly adhered to. If any other sequence is used, the developer becomes readily brownish-red and becomes unsuitable for work.

Contrasty and High Speed Metol-Hydroquinone Developer KTs-1

(TsNIIGAIK)

Metol	2 grams
Hydroquinone	10 grams
Sodium Sulphite crystalline	52 grams
Sodium carbonate anhydrous	40 grams
Potassium bromide	4 grams
Water	1,000 ml

The sequence of preparing and mixing the solutions is the same as for the universal metol-hydroquinone developer. This developer produces high contrast, which is particularly important for line negatives, it also works rapidly: at a temperature of 18-20° C the development lasts 4-5 minutes.

Rapid Two-Solution Hydroquinone Developer

First Solution

Warm water (50° C)	500 ml
Sodium sulphite anhydrous	40 grams
Hydroquinone	50 grams
Water (room temperature) to make	1,000 ml

Second Solution

Potassium hydroxide	300 grams
Room temperature water to make a total of	1,000 ml
Sodium hydroxide may be used to replace potassium hydroxide	210 grams

Both solutions are mixed and stored separately. The first solution is made up the same as for all other developers, with the solutions of the individual salts being mixed in the sequence indicated in the formula. This developer works rapidly and at considerably lower temperatures than those in which other developers work.

The negative is placed in the first solution and left there approximately for 10 seconds with the tray constantly rocked. After this, the negative is immersed without rinsing for a short time (1-3 seconds) into the second solution.

**Metol-Hydroquinone Developer for the Development of
Photographic Paper (Photomontage etc)**

Metol	2 grams
Hydroquinone	5 grams
Sodium sulphite crystalline	50 grams
Sodium carbonate anhydrous	30 grams
Potassium bromide	5 grams
Water	1,000 ml

The sequence of preparation and mixing of the solution remains the same as for other developers.

Acetic Acid Stop Bath

Acetic acid, 30%	120 ml
Water at room temperature	1,000 ml

The negative removed from the developer is immersed for 5-6 minutes in the stop bath to stop the action of the developer. This stop bath is used after developer in a carbonate alkali (soda).

Stop Bath With Sodium Acetate

Hot water (50°C)	500 ml
Sodium acetate anhydrous	50 grams
Sodium sulphate acid	100 grams
Water room temperature, to make	1,000 ml

The salts are each dissolved separately and the solutions are then mixed. Instead of acid sodium sulphate it is possible to use 10% solution of sulphuric acid. In this case the solution of sulphuric acid must be poured in carefully into the solution of the sodium nitrate, with the solution being vigorously stirred at all time.

The stop bath prepared from this formula is used after alkaline developers (developers with caustic alkalies).

When working at temperatures above 24-25° C it is advisable to harden the emulsion film and to prevent its excessive softening by treating the negative with a hardening solution.

Chrome Alum Hardening Solution

Chrome alum	30 grams
Water at room temperature	to 1,000 ml

The negative is treated in the hardening solution after development. The negative is immersed for 3-5 minutes in the hardening solution, after which it is carried over to the fixer.

Fixing Solution (Rapid, Neutral)

Crystalline hypo	350 grams
Ammonium chloride	50 grams
Water	1,000 ml

The hypo and the ammonium chloride are dissolved separately, and then two solutions must be filtered through cotton. It is possible to use 220-230 grams of anhydrous hypo instead of the crystalline hypo.

Acid Fixing Solution

Crystalline hypo	250 grams
Crystalline sodium sulphite	16 grams
Sulphuric acid (specific gravity 1.83)	1 ml
Water	1,000 ml

The hypo is dissolved first. After it is fully dissolved the sulphite is added to the solution. After the latter is fully dissolved the sulphuric acid is added. Before using, the solution must be stirred. 160 grams of unhydrous hypo can be used instead of the crystalline hypo.

Acid Hardening Fixing Solution (F-1)

Water heated to 50° C	600 ml
Crystalline hypo	250 grams
Crystalline sodium sulphite	30 grams
30% acetic acid	45 ml
Potassium alum	50 grams
Water at room temperature	to 1,000 ml

The hypo is dissolved in the warm water; then the sodium sulphite is added to the solution and after it is dissolved the acetic acid is added with constant mixing. The potassium chrome alum is dissolved separately in a small amount of water and the solution is added to the hypo solution with constant stirring. The finished solution is brought to a total volume of 1,000 ml by adding water at room temperature.

Solution for Intensifying Silver-Bromide Negatives**(Chrome Intensifier)**

Potassium bichromate	8 grams
Hydrochloric acid	6 ml
Water	100 ml

The potassium bichromate is dissolved in a small amount of warm water (50°). The solution is then cooled, and by adding room-temperature water it is brought to the required volume, after which the hydrochloric acid is added. The finished solution should be thoroughly stirred.

The negative is bleached in the above solution. The blackening (the final step in intensification) is carried out in one of the usual metol-hydroquinone developers.

60. Solutions and Compounds for Photo-Copying Processes

Two groups of solutions and compounds, one for negative and one for positive copying, are used in photo-copying processes.

Solutions and Compounds for Negative Copying**Starch Solution for Treating the Aluminum Plate Before Copying**

Cornstarch	20 grams
Water	1,000 ml

The starch is thoroughly mixed in 150 ml of water at room temperature. The remainder of the water is heated to the boiling point. The dissolved starch is poured gradually into the boiling water in a thin stream, constantly stirring, and then the solution is removed from the fire and filtered through gauze. The resultant paste is ready for use after cooling. Good results are obtained

only with a fresh solution of starch. As soon as water begins to separate from the starch it becomes unsuitable for work and should be replaced by a fresh one.

Solution for Preliminary Treatment (Cleaning) of the

Surface of Grained Zinc Plates Prior to Copying

Potassium alum	50 grams
Water	1,000 ml

The potassium alum crystals are crushed in a pestle and dissolved in water heated to 60° C. After the alums are completely dissolved, the solution is cooled and filtered through cotton or through gauze folded in four layers.

In the summertime it is preferable to use the following solution for preliminary treatment of grained zinc plates before copying.

Glacial acetic acid	50 grams
Water	1,000 ml

The acetic acid is poured into water in a thin stream with constant stirring.

To prepare the light-sensitive copying emulsion there is a great variety of different formulas. We give below certain formulas for light-sensitive emulsions for negative copying, which were tested many times in manufacture and gave good results.

Copying Solutions of Dry (Chinese) Chromated Egg Albumin

Egg albumin dry (Chinese)	45 grams
Ammonium bichromate	15 grams
25% ammonia	6 ml
Water	1,000 ml

The above quantity of albumin is placed in a bag made of two or three layers of cloth and immersed in a vessel with water for 6-8 hours until it is fully dissolved. The albumin solution is filtered through cotton. The ammonium bichromate is dissolved separately in water heated to 50-60° C. After cooling, the solution of the ammonium bichromate is poured into the solution of the albumin, constantly stirring. The last to be added is the ammonia. The ready solution must be thoroughly stirred. After a brief settling period, the solution is suitable for work.

Copying Solution of Dry (Domestic) Chromated Egg Albumin

Egg Albumin dry (domestic)	36 gram
Water	700 ml
Ammonium bichromate	10 grams
Water	50 ml
Ammonia 25%	4 ml

The albumin is soaked in 700 ml warm water (35-40° C), mixed until the lumps disappear, and remain for swelling and dissolution for 12-16 hours. The ammonium bichromate is dissolved separately in hot water (60° C). After the ammonium bichromate solution has cooled, it is poured into the albumin solution, constantly stirring. The last to be added to the solution is the ammonia. The ready solution is filtered through cotton.

Copying Solution of Dry Chromated Egg Albumin (TANIIGA1K

Formula)

Egg albumin dry	40 grams
Ammonium bichromate	16 grams
25% ammonia	6 ml
Water	1,000 ml

The solution is prepared in the same manner as the previous one, and is suitable for operation twelve hours after preparation.

Copying Solution of Chromated Blood Albumin

Blood albumin	30 grams
Ammonium bichromate	12 grams
Ammonia 25%	12 ml
Water	1,000 ml

The sequence in the preparation of the copying solution is the same as used with dry egg albumin.

Copying Solution of Liquid Chromated Egg Albumin

(or White of Fresh Eggs)

Liquid albumin (settled)	275 ml
Ammonium bichromate	23 grams
Ammonia 25%	10-12 ml
Water	1,000 ml

The liquid albumin (or the white of fresh eggs) is beaten into a foam and left to settle. After the liquid albumin has fully settled, the foam is removed and the separated liquid albumin is dissolved in 50 ml of water. The resultant solution is filtered through cotton. The ammonium bichromate is dissolved separately in 500 ml of hot water (60° C). The solution is filtered after cooling and poured into the albumin solution, constantly stirring. The ammonia is then added to the solution, also stirring. The solution prepared in accordance with this formula is ready for use after twelve hours.

When copying solution is prepared from the white of fresh eggs it is necessary to see to it that not even a trace of yolk enters into the egg white, or else the solution will be unusable.

Copying Ink for Rolling the Plate After Exposure

Transfer ink No 82	100 grams
Black offset ink	100 grams
Rectified turpentine	150 ml

Both inks are placed in a tin-plate vessel and covered with turpentine. By thoroughly mixing, they are dissolved in the turpentine and are mixed well with each other. As the turpentine evaporates and the ink becomes thick, it is again thinned by addition of turpentine.

Solutions and Compounds for Positive Copying.**Solution for Treating the Surface of****Aluminum Plates**

Sulphuric acid (specific gravity 1.84)	10 ml
Water	1,000 ml

When preparing the solution the acid must be poured into the water and not vice versa.

Solution for Treating the Surface of Zinc Plates

Potassium alum	30 grams
Nitric acid	5 ml
Water	1,000 ml

The alum is dissolved in water and the acid is added to the solution.

As in the case of negative copying, there are many formulas for copying solutions intended for positive copying. Certain formulas, which gave favorable results and were checked many times in manufacturing conditions are given below.

Copying Solution of Chromated Gum-Arabic

(a) Gum arabic	150 grams
Water	600 ml
(b) Ammonium bichromate	30 grams
Water	400 ml

The gum-arabic is ground in a pestle, poured in a gauze bag, and immersed in a vessel with 600 ml of water. All the gum arabic must be immersed in the water, and the bag must not touch the bottom or the walls of the container. The gum arabic immersed in the water is left there for swelling and dissolution for several days. After the gum arabic is dissolved, the solution is filtered through cotton. The ammonium bichromate is dissolved separately in hot (60° C) water and after the solution is cooled it is poured into the solution of the gum arabic, with constant stirring. The specific gravity of the finished solution should be 1.06 at 18° C. This is achieved either by adding water (if its specific weight is greater), or by adding solution of gum arabic (if it is less).

The ready solution should settle well, so that the minute insoluble remnants are separated, for they may complicate the preparation of the printing form. The copying solution can therefore be used not earlier than twelve hours after it is prepared.

Copying Solution of Chromated Mixture of Gum Arabic**with Resin of Siberian Larch**

Solution of gum arabic (specific gravity 1.08 at 18° C)	500 ml
Solution of resin of Siberian larch (specific gravity 1.08 at 18° C)	500 ml
Ammonium bichromate	500 grams
Water	250 ml

As indicated above, 500 g of gum arabic is moistened in 50 ml of water (in the case of the formula calling for copying emulsion made of gum arabic) and left for 10-12 hours (until fully dissolved). The solution is then filtered through cotton and its specific gravity is checked, making it 1.08 at 18° C (using the methods indicated above).

Resin of Siberian larch (1500-2000 grams) is pulverized, placed in a gauze or calico bag and immersed in a vessel (the same as indicated for gum arabic) with 500 ml of water. The vessel is heated to a temperature of 60° C. This causes the resin to dissolve within 2-3 hours. The cooled solution is filtered through cotton and its specific gravity is made to be 1.08 at a temperature of 18° C. The solution of the resin must be filtered particularly carefully, for it contains a particularly large amount of insoluble particles. After filtering and before mixing with the gum arabic, the solution of resin of Siberian larch should be left to settle for 2-3 days. The settled solution is poured off, filtered again, its specific gravity is again checked, and if necessary it is brought up to 1.08 at 18° C. After this equal volumes (500 ml each) of solutions of gum arabic and resin are mixed together.

The ammonium bichromate is dissolved separately in hot water, and the cooled solution is added to a mixture of solution of gum arabic and resin. The ready solution is filtered through tricot cloth folded in three layers.

The finished solution should be left to settle, for even filtering twice or three times does not rid it of minute particles, which may complicate the subsequent process. After settling for

several days, the solution can be used for work.

Copying Solution Made of Mixture of Chromated Resin of
Siberian Larch and Albumin

(a) Solution of resin of Siberian larch (specific gravity 1.143-1.145 at 18° C)	600 ml
Ammonium bichromate	18 grams
Water	200 ml
(b) Egg albumin dry	50 grams
Water	600 ml
Ammonium bichromate	16 grams
Water	200 ml

Solutions a and b are prepared in accordance with the rules and sequence indicated above, and are then mixed and filtered. The finished solution is left to stand for not less than 12 hours, after which it can be used.

Copying Solution of Chromated Mixture of Apricot (Dried Apricot)
Resin and Resin of Siberian Larch (ASL)

Solution of apricot resin	500 ml
Solution of resin of Siberian larch	500 ml
Ammonium bichromate	50 grams
Water	150 ml

The apricot resin powder (50-60 grams per 1,000 ml of water) is soaked in water at room temperature and is dissolved, systematically stirring until all lumps disappear. The solution is then poured into tall containers and is left to settle for 3-4 days. The settled solution is poured off, filtering it through cotton, its viscosity is checked and is adjusted until it takes 30 seconds for it to pour from a pipette with 0.2 mm diameter and 25 ml volume.

The solution of the Siberian-larch resin is prepared as indicated above. Its specific gravity is adjusted to 1.08 at a temperature of 19° C. Both solutions are mixed and the separately prepared solution of ammonium bichromate is added to them. Before it is used, the ready solution should settle for not less than 12 hours.

Copying Solution of Chromated Mixture of Siberian Larch

Resin and Polyvinyl Alcohol (SPSL-1 -- TsNIIGAIK
formula)

Solution of polyvinyl alcohol (relative to the total volume of the finished compound)	20%
Solution of Siberian-larch resin (relative to the total volume of the finished compound)	80%

Dry powdered polyvinyl alcohol (50 grams per 1,000 ml of solution) is moistened in water (900 ml per liter of solution) at room temperature and left to swell. Since the powder of the polyvinyl alcohol can form lumps, they must be first broken up in a pestle and the mixture must be constantly stirred as it swells. To produce the swelled mixture, the weighed amount of polyvinyl alcohol is poured in small batches into the measured volume of water. After 2-3 hours of swelling the moistened powder of the polyvinyl alcohol is molten in a water bath at a temperature of 90° C. The solution thereby becomes transparent. Ten grams of ammonium bichromate are dissolved separately in 100 ml of hot water, and after the two solutions are cooled they are filtered and mixed together.

The chromated solution of the Siberian-larch resin is prepared separately from the polyvinyl alcohol solution using the

sequence indicated above for similar solutions. With this, 800 ml of the Siberian larch resin solution are mixed with 18 grams of ammonium bichromate dissolved in 200 ml of hot water.

Both chromated solutions (of the polyvinyl alcohol and of the Siberian larch resin) are mixed together in the proportions indicated above (by volume), forming a copying light-sensitive solution. The finished solution must be filtered again. The solution is ready for use several (4-8) hours after preparation.

When stored for a long time, a mixture of polyvinyl alcohol and Siberian larch resin may separate out. It is therefore not advisable to prepare the compound more than 2-3 days ahead. Before using, the solution should be lightly stirred together.

Copying Solution of Chromated Siberian Larch Resin

(VNIIPiTa Formula)

Solution of Siberian Larch resin (specific gravity 1.12)	800 ml
Ammonium bichromate	70 grams
Potassium permanganate	0.2 grams
Acid azure dye	0.1 grams
Water	200 ml

The solution is prepared in the same manner as analogous solutions indicated above.

Developer for Copying Emulsion Made of Chromated Gum-

Arabic and Siberian-Larch Resin

Solution of calcium chloride (specific gravity 1.32)	1,000 ml
60% lactic acid (specific gravity 1.19)	60 ml

The calcium chloride (600-700 grams) is dissolved in 500-600 ml of hot (60-70°C) water. After all the calcium chloride is dissolved and the solution is cooled, it is adjusted to the required specific gravity, by adding water (if it is too concentrated). The specific gravity of the finished solution of calcium chloride should be 1.32 at a temperature of 20° C. The finished solution is filtered through a filter paper and the indicated amount of lactic acid is added to it, with constant stirring.

If 90% lactic acid is on hand, it need not be diluted separately, and it is better to add 40 ml (instead of 60 ml of 60%) to the solution. If the lactic acid on hand is in the form of a paste (usually 80%) it is necessary to dissolve it gradually in small pieces, making sure that they are well dissolved. If such a paste is used, 50 grams of it should be added to the solution of potassium chloride. The solution is ready for work as soon as it is prepared.

Developer for Copying Emulsions made of Chromated

Gum Arabic and for Copying Emulsions made of Chromated

Albumin and

Calcium Chloride Solution (specific gravity 1.4)	956 ml
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90% lactic acid	40 ml
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or

60% lactic acid	60 ml
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or

lactic acid in the form of paste (80%)	50 grams
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The sequence of preparation is the same as described above.

Developer for Copying Emulsion Made of a Mixture of Chromated**Polyvinyl Alcohol and Chromated Siberian Larch Resin**

Calcium chloride solution (specific gravity 1.34)	1,000 ml
Lactic acid 60%	65 grams

The sequence of preparation is the same. The specific gravity of the finished developer should be 1.32 at 20° C.

Developer for Copying Emulsion made of Mixture of Chromated**Apricot Resin and Chromated Siberian-Larch Resin**

Calcium chloride solution (specific gravity 1.32)	1,000 ml
Lactic acid 60% (specific gravity 1.19)	35 ml

It must be remembered that calcium chloride is a highly hygroscopic salt and that its solutions are also hygroscopic. The developer must therefore always be stored in vessels with ground glass stoppers. In the absence of lactic acid it can be replaced with weakly-dissociating organic acid (acetic or formic). In the same considerations and amounts as indicated in the formulas for lactic acids.

Developer for Copying Solutions made of Chromated Siberian**Larch Resin and of its Mixtures with Other Colloids****(VNII of the Glavizdat)****(a) For Aluminum**

Glycerine (specific gravity 1.18)	800 ml
Solution of ammonium thiocyanate	200 ml

Adding water, the specific gravity of the glycerine is adjusted to 1.18. The ammonium thiocyanate solution is prepared separately using the following formula:

Ammonium thiocyanate	300 grams
Water	700 ml

The solution of ammonium thiocyanate is mixed with the glycerine. The specific gravity of the finished solution should be 1.16.

(b) For Zinc

Glycerine (specific gravity 1.20)	700 ml
Solution of ammonium thiocyanate	300 ml

The sequence of preparation of the solution is the same.
Solution for Deepening the Printing Elements (etching) on the Basis
of Ferric Chloride

(a) For Aluminum

Ferric chloride (in lumps or powder)	400 grams
Rectified alcohol 96%	800 ml
Glycerine	150 ml
Hydrochloric acid (specific gravity 1.19)	15 ml

The ferric chloride is dissolved in alcohol in a porcelain dish with constant stirring. The glycerine and hydrochloric acid are added in sequence into the ready ferric-chloride solution. The solution is ready for use immediately as soon as it is prepared.

(b) For Zinc

Ferric chloride (in lumps or powder)	400 grams
Rectified alcohol - 96%	80 ml
Glycerine	150 ml

The sequence of preparation is the same as indicated above.

Solution for Deepening the Printing Elements (Etching)
On the Basis of Caustic Alkalies and Ammonium Thiocyanate

(a) For Aluminum

Ammonium thiocyanate	400 grams
Water	600 ml
Potassium (or sodium) hydroxide	100 grams
Water	200 ml

The first and second solutions are stock components of the finished compound. The working solution for the despending of printing elements is compounded according to the following formula:

Glycerine (specific gravity 1.22)	500 ml
Mixture of first and second solutions (in the amounts indicated in the formula)	500 ml

The ammonium thiocyanate in the amount indicated above is dissolved in 600 ml of water. 100 grams of potassium or sodium hydroxide are dissolved separately in 200 ml of water. Both solutions are mixed together. The glycerine is adjusted to a specific gravity of 1.22 and the required amount is then added to the mixture of the first and second solutions. The specific gravity of the ready solution should be 1.17-1.18.

(b) For Zinc

Glycerine (specific gravity 1.22)	500 ml
Solution of ammonium thiocyanate	500 ml

The solution of ammonium thiocyanate is prepared in accordance with the following formula:

Ammonium thiocyanate	500 grams
Water	500 ml

The solutions are prepared separately and then are mixed in the amounts indicated in the formula. The specific gravity of the ready compound should be 1.17-1.18.

Bakelite Lacquers for the Preparation of the Forms for Positive Copying**First Formula**

Bakelite lacquer	100 ml
Butyl alcohol	400 ml
Methyl violet or fuchsin dye	1-2 grams

Second Formula

Bakelite lacquer	54 ml
Butyl alcohol	250 ml
Methyl violet or fuchsin dye	0.5-1.0 grams

The dye is first dissolved in the indicated amount of butyl alcohol. After it is fully dissolved the bakelite lacquer is added to it, stirring constantly and vigorously. The solution is ready for use immediately after preparation. The solution of lacquer must be stored during work in a closed vessel, for when the volatile butyl alcohol is evaporated its concentration may change.

Shellac Lacquer for Preparation of Printing Forms for Positive Copying

Shellac	50 grams
Ethyl alcohol 96%	1,000 ml

The shellac is covered with alcohol and left for 2-3 hours to swell. Since the shellac dissolves very slowly in alcohol at ordinary temperature, it is heated in a water bath until fully dissolved. With this, the solution must always be stirred. After cooling, the compound is ready for use. As in the case of the bakelite lacquers, it must be stored in covered vessels (best of all in small bottles or in flasks with ground stoppers), so

that solution concentration does not change by evaporation of the alcohol.

Lacquer Compound for Effecting Corrections on Printing

Forms (TsNIIGAIK Formula)

Bakelite lacquer	200 ml
Ethylene glycol	270 ml
Ethyl alcohol 96%	48 ml
Methyl violet or fuchsin dye	1.6 grams
Granular soap 80% (dry powder)	1.1 grams
Butyl Acetate	15 ml

Measured quantities of bakelite and lacquer and ethylene glycol are poured together, the solution being thoroughly and vigorously stirred at the same time. The dye, grounded into a fine powder, is added to the mixture of bakelite lacquer and ethylene glycol, thoroughly stirring the solution at all times.

A solution of soap in ethyl alcohol is prepared separately. For this purpose soap is cut into small pieces and dried. The dry soap is ground into a fine powder, which is dissolved in the ethyl alcohol. The soap solution so prepared is poured into the mixture of bakelite lacquer with ethylene glycol (after adding the dye) and thoroughly stirred. The last to be added to the compound is the butyl acetate. The ready solution is thoroughly mixed, after which it is ready for use. As in the case of other lacquer compounds, this must be stored also in tightly covered vessels.

Ink for Preparation of Printing Forms by Positive Copying

Transfer ink No. 82	100 grams
Black offset ink	100 grams
Rectified turpentine	150-200 ml

The inks are thoroughly mixed (rubbed) and diluted in turpentine. The turpentine rapidly evaporates from an open container and the ink becomes denser.

In the absence of ready transfer and offset inks it is possible to prepare ink for the preparation of printing forms by positive copying in accordance with the following formula:

Gas lamp black	300 grams
Tallow	85 grams
Beeswax	411grams
Weak drying oil	650 grams
Neutral soap	16 grams
Kerosene	500 ml
Amyl acetate	25 ml

The wax, tallow, soap, and drying oil is molten together on a water or sand bath at a temperature of 60-70° C. The molten composition is thoroughly mixed and the lampblack is added to it. The composition is continued to be carefully heated for an hour, with thorough stirring all the time. The compound is then removed from the flame and after it is cooled to a temperature not above 40° the kerosene and amyl acetate are carefully added to it, with constant stirring. The ready compound is left to cool, after which it is passed once or twice through a paint grinder. The compound is ready for work immediately after it is prepared.

Formulas for Tinctures for Greasing Printing Elements on the Printing Forms

First Formula

Syrian asphalt	120 grams
Oleic acid	72 grams

Beeswax	12 grams
Turpentine	750 ml

The asphalt, oleic acid, the wax, and one tenth of the turpentine are mixed and molten on a water bath at a temperature of 60-70° C, with continuous and thorough stirring. After all the components are molten and the solution is cooled, the remainder of the turpentine is added with thorough stirring.

Second Formula

Bitumen	150 grams
Beeswax	40 grams
Rosin	25 grams
Linseed oil	105 grams
Turpentine	1,000 ml

The bitumen, wax, rosin, and linseed oil are molten in part of the turpentine, after which the rest of the turpentine is added.

The tincture must be prepared with great care so that it does not catch fire.

61. Iron-Salt Solutions and Compounds for the Preparation of Copies

Solution for Preparation of Blueprint Copies

Solutions for Producing Copies on Paper in Two Steps

(NRECh Formula)

(a) Light Sensitive Solution

Citrate of iron and ammonia (brown)	40 grams
Citric acid	60 grams
25% ammonia	25 ml
Distilled water	550 ml

(b) Solution for Developing the Copy

Potassium ferricyanide	50 grams
Distilled water	1,000 ml

The citrate of iron and ammonia is first dissolved in hot water (60-70° C), stirring the products constantly during the dissolution. After the iron salts are thoroughly dissolved, the citric acid is dissolved. The solution is left to cool and the ammonia is added in small batches, with constant stirring. The finished compound is filtered through cotton.

The potassium ferricyanide is dissolved separately and is also filtered through cotton.

The solutions are kept each in an individual vessel for operation.

When working with solutions of the above composition, the resultant image is intense. To obtain a weaker or azure image, the light sensitive solution can be diluted with distilled water.

The solutions (particularly the light-sensitive one) must be stored in a dark cool place in a brown-glass vessel or in a vessel that is covered on the outside with black paper.

Solution for Carrying Out the Process in Two Steps

(Northwest AGP Formula)

(a) Light-Sensitive Solution

(1) Citrate of ammonia and iron (brown)	20 grams
Distilled water	60 ml
(2) Citric acid	28 grams
Distilled water	280 ml
(3) Potassium chrome alum	28 grams
Distilled water	280 ml

All the reagents -- the citrate of ammonia and iron, citric acid, and potassium chrome alum -- are dissolved separately in the indicated amounts of water. The solutions are then poured together and the ready compound is filtered through cotton.

(b) Solution for Developing the Copy

Potassium ferricyanide	30 grams
Distilled water	1,000 ml

The potassium ferricyanide is dissolved in the indicated amount of water and filtered through cotton.

The sequence of application and the storage conditions of the solution are the same as indicated for that previous formula.

Given below are, for the sake of information, various solutions to obtain blue copies on metal. The first formula is recommended.

Solution for Carrying out the Process in a Single Step

First Formula

(a) First stock solution

Citrate of ammonia and iron (brown)	125 grams
Oxalic acid	25 grams
Citric acid	50 grams
Distilled water	1,000 ml

(b) Second stock solution

Potassium ferricyanide	40 grams
Distilled water	1,000 ml

Both stock solutions are prepared the same as indicated above for the light-sensitive solution and developer. The oxalic acid is dissolved here after the citric acid. Each of the solutions is

filtered through cotton, and they are mixed in equal proportions (1:1). The solutions must be mixed immediately before using.

The storage method is the same as indicated above for other formulas.

Solution for Intensifying the Blue Image

Concentrated nitric acid	20 ml
Concentrated hydrochloric acid	10 ml
Water	1,000 ml

The nitric acid is first dissolved and the hydrochloric acid is then added with stirring. The solution is ready for use immediately after it is prepared.

Second Solution

(a) First stock solution

Citrate of iron and ammonia (brown)	75 grams
Citric acid	60 grams
12.5% ammonia	45 ml
Distilled water	90 ml

(b) Second stock solution

Potassium ferricyanide	20 grams
Distilled ater	1,000 ml

Both stock solutions are prepared in the same sequence and under the same conditions as indicated above. To prepare the working compound, the first and second solutions are mixed in the following proportions:

First stock solution	30 ml
Second stock solution	50 ml

The working compound is prepared directly before use, owing to its low stability.

Third Formula

(a) First stock solution

Citrate of ammonia and iron (brown)	25 grams
Citric acid	5 grams
Oxalic acid	10 grams
Distilled water	200 ml

(b) Second stock solution

Potassium ferricyanide	40 grams
Distilled water	1,000 ml

The working compound is prepared by mixing the first and second stock solution directly before using in equal amounts (1:1).

Solution of Potassium Permanganate for Treating the Surface of the Plate Before Coating the Light-Sensitive Emulsion

Potassium permanganate	10 grams
Water	1,000 ml

The potassium permanganate is dissolved with constant stirring.

Acid Solutions for Intensification of the Image

First Formula

Concentrated nitric acid	20-30 ml
Water	1,000 ml

The acid is carefully poured into the water with constant stirring.

Second Formula

Concentrated nitric acid	20 ml
Concentrated hydrochloric acid	10 ml
Water	1,000 ml

The nitric acid is first dissolved carefully in water, with constant stirring. The hydrochloric acid is added next, also stirring. In both the first and second formulas the solution is ready for use immediately upon preparation.

Solutions and Compounds for the Preparation of Argentotype

(Brown) Copies [Van Dykes]

Light-Sensitive Solution

(a) First stock solution

Citrate of ammonia and iron (brown)	10 grams
Citric acid	10 grams
Distilled water	200 ml

(b) Second stock solution

Silver nitrate	10 grams
Distilled water	100 ml

The citrate of ammonia and of iron is first dissolved in water heated to 60-80° C, after which the citric acid is added. The solution is left to cool. The silver nitrate is dissolved separately. The first and second stock solutions are then mixed and the ready compound is filtered through cotton.

The resultant compound is very unstable under the influence of light. It must therefore not be prepared in large amounts (for more than 2-3 days of work), and secondly it must be stored in a dark place and in a vessel made of brown glass, or better still, covered on the outside with black paper.

Only the ferric citrate should be used for the solution, and furthermore, it must be absolutely free of impurities of ferrous citrate. This can be checked as follows. A solution of potassium ferricyanide is added to a solution of citrate of iron and ammonia.

If the iron solution assumes an azure color, potassium permanganate is added to the solution until the color of the iron solution becomes brownish. Usually one ml of a 2% solution of potassium permanganate per 100 ml of solution is enough for the purpose.

Fixing Solution

Hypo (sodium thiosulfate)	100 grams
Sodium sulphite	50 grams
Water	1,000 ml

The hypo and the sodium sulphite are completely dissolved and cooled, the solutions are mixed and filtered through cotton.

Solution for Reducing Argentotype Copies

Potassium ferricyanide	10 grams
Hypo	40 grams
Water	1,000 ml

The solution is prepared in the same manner as the so-called Farmer's reducer, and is used the same way.

62. Solutions and Compounds Used to Coat Glass and Plastic with Silver-Bromide Emulsions

Solution for Substratum of Glass Plate

Photographic Gelatine	5 grams
Chrome alums (10% solution)	4.5 ml
Ethyl alcohol rectified (98%)	25 ml
Phenol (50% alcohol solution)	4 ml
Distilled water	1,000 ml

The gelatine is moistened with a small amount of water and after it swells it is dissolved in a water bath. The gelatine solution is brought to the required volume, adding the remainder of the water. Then one adds to the cooled solution of gelatine

first the alum, then the phenol solution, and finally the alcohol. All the solutions are added with constant stirring. After the solution is finally prepared it is filtered through cotton.

The solution is ready for work after 2-3 days. It is necessary to store the compound in a cool place at a temperature not higher than 15-16° C.

Solution for Substratum for "Viniproz" Plates

To prepare the compound one first mixes three stock solutions:

(a) First stock solution

Photographic gelatine	18 grams
Distilled water	37.5 ml

(b) Second stock solution

Glacial acetic acid	150 ml
Rectified ethyl alcohol (96%)	100 ml

(c) Third stock solution

Acetone	1,400 ml
Rectified ethyl alcohol (96%)	1,500 ml
Celluloid photographic film (cleared of emulsion and washed)	20 grams
Butyl alcohol	500 ml

The above amount of gelatine is moistened in distilled water and left for 5-6 hours to swell, after which it is dissolved in a water bath. The celluloid photographic film is dissolved in the acetone. After it is fully dissolved the solution of the film is left to settle. The settled solution is poured off and ethyl and butyl alcohol are added to it. The acetic acid solution in ethyl alcohol is prepared in the usual sequence.

After preparing all three stock solutions the final working preparation is prepared. For this purpose solution b is poured

into solution a. Solution c is then added to the mixture slowly, with constant stirring. The finished compound is suitable for work after 1-2 days.

Glue for Attaching Plastic (Photographic Film and
"Viniproz and Astralon" Plastics) to Glass

First Formula

Gum Arabic 25% solution	250 ml
Gelatine	150 grams
Urea	150 grams
Triglycol (or glycol)	50 ml

A 25% solution of gum arabic (250 grams in 1,000 ml of water) is first prepared. The gelatine is moistened in the solution and is left there for several hours to swell, after which it is melted by heating in a water bath. In the thus prepared solution of gum arabic and gelatine one adds first the urea, and after it is dissolved and mixed, the triglycol (or glycol) is added. The ready compound is suitable for work after 5-6 days.

Second Formula

Solution of Siberian-larch resin (specific gravity 1.08-1.09)	250 ml
Medium gelatine	200 grams
Urea	150 grams
Triglycol (or glycol)	50 ml

The sequence of preparation is the same as for the previous formula. The compound is ready for use within 5-6 days.

63. Compounds for the Preparation of Duplicates of Negatives and Positives Using the Wash-Off Relief and Selective Coloring Method.

Light-Sensitive (Copying) Solution for the Wash-Off Relief Method

Gelatine (soft or medium)	70 grams
Ammonium bichromate	15 grams
Petrov's "contact" [adhesive]	10 ml
Water	1,000 ml

The gelatine is moistened in part of the water and after swelling for 5-6 hours it is dissolved over a water bath, with constant stirring. The ammonium bichromate is dissolved separately in hot water (70-80°C). Both solutions are mixed and the Petrov's "contact" is added to this mixture. The ready compound is filtered through cotton. The solution is used warm (35-40° C).

Solutions for Coloring the Negatives and Positives

Direct black dye "3-200%" or "K"	40 grams
Water	1,000 ml

The dye is dissolved by mixing in hot (70° C) water. After the solution is cooled it is filtered through cotton. The solution is ready for use immediately after preparation.

Hardening Solution

Chrome alum	15-20 grams
Water	1,000 ml

The alum is dissolved in hot (70° C) water. After the solution has cooled, it is filtered through cotton.

Light-Sensitive (Copying) Emulsion for the Selective-Coloring Method

Gelatine (soft or medium)	70 grams
Ammonium bichromate	30 grams
Petrov's contact	10 ml
Water	1,000 ml

The method of preparation is the same as indicated in the formula for the copying emulsion for wash off relief.

BIBLIOGRAPHY

1. James, T., Higgins, J. "Principles of the Theory of the Photographic Process" (Russ. Transl.), Foreign Literature Publishing House, Moscow, 1954
2. Zolotnitskiy Yu. I., "Preparation of Deep-Offset Forms," Gizelegprom, Moscow, 1948
3. "Instruction on the Photographic Operations in the Publication of Geographic Maps and Atlases," Geodezizdat, Moscow, 1952
4. "Instruction on the Preparation of Forms by the Negative and Positive Copying Method for the Printing of Geographic Maps and Atlases," Geodezizdat, Moscow, 1952
5. "Instruction on the Printing with an Offset Proof Press for the Publication of Geographic Maps and Atlases," Geodezizdat, Moscow, 1952
6. "Instruction on the Copying of Aluminum and Zinc Plates for Offset Printing of Geographic Maps and Atlases," Geodezizdat, Moscow, 1952
7. Katushev Ya. M., Sheberstov V. I., "Principles of the Theory of Photographic Processes," izd-vo "Iskusstvo," Moscow, 1954
8. Kirillov, N. I., "Fundamentals of Processing of Photographic Materials"
9. Lapatukhin V. S., "Diffusion Phenomena in Chrome-Albumin Emulsions in the Preparation of Offset Printing Forms," VNITO poligrafii i izdatel'stva, 1949
10. Lapatukhin V. S., "Physico-Chemical Fundamentals of Offset Processes," Gos. izd-vo "Iskusstvo" 1952

11. Mees, K., *Theory of the Photographic Process* (Russ. Transl)
GITTL, Moscow, 1949
12. Mikhaylov, V. Ya., "Photography and Aerial Photography,"
Geodezizdat, Moscow, 1952
13. Pus'kov, V. V., "Photomechanics," Gizlegprom, 1938
14. "Technology of Map Publishing," part I, Geodezizdat, Moscow, 1940
15. Pus'kov, V. V., "Technology of Map Publishing," part II, Geodezizdat, M.
Moscow, 1946
16. Pus'kov, V. V., "Technology of Map Publishing," Geodezizdat,
Moscow, 1954
17. Pus'kov, V. V., Notkina, N. M., "Photomechanical Processes
in Relief Printing," Gizlegprom, Moscow, 1950
18. Safonov, A. P., Perikov, V. M., Sinyakov, N. I., "Map-Publish-
ing Processes and Reproduction Photography," Voenizdat,
Moscow, 1949
19. Eder, I. M., "Phototechnical Handbook for Polygraphists,"
Gizlegprom, Moscow, 1933
20. Sinegub-Lavrenko, A. A., "Preparation of Printing Forms by
the Glue Method of Deep Offset in the Publication of Maps,"
Trudy TsNIIGAik [Transactions of the Central Scientific
Research Institute for Geodesy, Aerial Photography, and
Cartography], No 71, Geodezizdat, Moscow, 1949
21. Eder, I. M. "Die theoretischen und praktischen Grundlagen der
Autotypie," Halle (Saale), 1928

FIGURE CAPTIONS

Figure 1. Relative Visibility

Relative coefficient of visibility

Figure 2. Light-Sensitivity of Various Photographic Materials

(I -- silver chloride, II -- silver bromide, III -- silver
iodide)

Figure 3. Light Flux passing through a body, absorbed, and reflected

F_{inc}

F_{ref}

F_{abs}

F_{tr}

Figure 4. Crystal lattice

Figure 5a. Developed grain

Figure 5b. Exposed but undeveloped grain

Figure 6a. Successive stages in the development of silver-halide crystals

Figure 6b. Successive stages in the development of grains of silver-bromide emulsions

Figure 7. Microphotographs of developed and undeveloped emulsion grains

Figure 8. Sequence of Development (Scheme)

Figure 9. Photograph of a section, showing the successive stages of the development of the photographic emulsion

Figure 10. Disc of the Hurter and Driffield sensitometer

Figure 11. Various types of optical wedges

a -- continuous, b -- stopped

Figure 12. Blank graph (GOI)

$H = (\text{lux-second})$ $S = (\text{GOST units})$

Figure 13. Characteristic curve

Figure 14. Family of Characteristic curves

$H = (\text{lux-second})$ $S = (\text{GOST units})$

Figure 15. Determination of the contrast coefficient

Figure 16. Determination of photographic latitude

Figure 17. Horizontal photographic camera

Figure 18. Suspended photographic camera

Figure 19. Two-room photographic camera

Figure 20. Diagram showing cassette difference

Figure 21. Calculation of cassette difference

Figure 22. Effect of Lack of parallelism of plane of screen and that
of ground glass

Figure 23. Path of rays in lens

Figure 24. Conjugate foci

Figure 25. Diagram of spherical aberration

Figure 26. Comma

Figure 27. Diagram of chromatic aberration.

Blue Yellow Red

Focal planes

Figure 28. Astigmatism

Figure 29. Distortion

Diaphragm

Diaphragm

Figure 30. Curvature of field

Figure 31. Path of rays in prism

Figure 32. Diagram showing effect of inverting mirror

Figure 33. Photograph of Petrov arc

Figure 34. Table for pouring silver bromide emulsion on plate.

1 -- first section, 2 -- second section, 3 -- support for
levelling the glass, 4 -- glass, 5 -- movable carriage, 6 --
pouring vessel, 7 -- container with ice

Figure 35. Diagram of drying cabinet for drying silver-bromide photo-
graphic plates.

Filters

Figure 36. Schematic plan of laboratory for the preparation of dry
silver bromide photographic plates.

1 -- pouring table, 2 -- cabinet for drying the plates with the
coated substratum, 3 -- sink for washing the filling vessel,

4 -- stand for glass, 5 -- working table, 6 -- drying cabinet for drying large photographic plates, 7 -- drying cabinet for drying small photographic plates, 8 -- working table, 9 -- table for preparation of emulsion, 10 -- thermostatic bath, 11 -- refrigerator, 12 -- covered shelving for storage of finished photographic plates

Figure 37. Pouring vessel

Overall view Section AA, side view

Figure 38. Diagram of relative placement of photographed object, its image, and the objective during the reproduction.

Objective

L -- photographed object, l -- image of photographed object

Figure 39. Effect of parallax in the measurement of the dimensions of the image on the ground glass

Figure 40. Dependence of optical density of image on the pH of the developing solution for various developers.

Density	Metol	Pyrogallol	Hydroquinone	Para-aminophenol
			Glycine	Para-phenyldiamine

Figure 41. Dependence of the resolving power (R), optimum exposure (H), blackening density (D) and contrast coefficient (γ) of reproduction plates on the duration of the development.

Resolving power	lines/min	γ , optimum D, and optimum H (in arbitrary units)
	min.	
	Observation time	

Figure 42. Dependence of the density of the image and of the density of the fog on the duration of the development in para-aminophenol (left) and metol (right) developers (V. I. Shebresov): curves I and II -- for two exposures, curve III -- for fog.

Density	min.
Duration of development	

Figure 43. Curve for the dependence of the blackening density on the duration of the development for various pH of the developer (V. Reinders and M. Moykers):

I -- hydroquinone developer with borax; II -- metol developer with borax, III -- para-aminophenol developer with borax

Figure 44. Comparative fixing speed of negative and positive emulsions:

I -- negative film; II -- positive.

Clearing time

Concentration of thiosulfate

Figure 45. Effect of size of silver-halide crystals on the speed of fixation.

1 -- average diameter of emulsion grain 3 micron, 2 -- 1.2 micron, 3 -- 0.7 micron.

Amount of dissolved silver halide

min

Figure 46. Schematic section through negative made by the wet-collodion method:

A -- opaque background, B -- transparent drawing, 1 -- base, film, etc, 2 -- nitrocellulose film, 3 -- intensification layer, consisting of finely-dispersed metallic silver (intensification layer); 4 -- layer of retouching ink

Figure 47. Ability of eye to distinguish individual image elements (scheme)

Figure 48. Magnified drawing of screen.

Figure 49. Diagram showing formation of screen image

Figure 50. Magnified drawing of gradual transition from light to shadow, obtained by photography through a screen

Figure 51. Diagram showing dependence of size of screen dots on variable factors

Figure 52. Diagram showing relief-printing form.

1 -- printing element, 2 -- blank element, 3 -- layer of printing ink on printing elements, 4 -- material of printing form

Figure 53. Diagram of intaglio printing form

1 -- printing element, 2 -- blank element, 3 -- layer of printing ink located in the recessions of the printing elements, 4 -- material of printing form

Figure 54. Diagram illustrating free surface energy

Figure 55. Diagram showing transformation of a hydrophilic surface into a hydrophobic one.

Non-polar hydrophobic group

Hydrophobic surface

Polar hydrophilic group

Hydrophilic surface

Figure 56. Diagram showing transformation of hydrophobic surface into a hydrophilic one.

Polar hydrophilic group

Hydrophilic surface

Non-polar hydrophobic group

Hydrophobic surface

Figure 57a. Drop of water on hydrophilic surface

Figure 57b. Extreme wetting angle

Figure 58. Less hydrophilic surface and corresponding extreme angle

Figure 59. Hydrophobic surface and corresponding extreme angle

Figure 60. Schematic illustration of modern litho-offset printing form

1 -- metal, 2 -- hardened albumin layer, 3 -- printing ink, 4 -- mineral layer on blank spaces

Figure 61. Microphotograph of polished section of transverse section of offset printing form on aluminum made by the positive-copying method (deep offset, magnification 500).

I -- metal, II -- lacquer, III -- ink layer

Figure 62. Schematic illustration of the effect of imperfect contact between the negative and the form plate in the copying frame

Figure 63. Control-Measuring rule

1 -- rectangular rule, 2 -- indicators, 3 -- movable supports
bed

Figure 64. Diagram showing path of light rays through superimposed red and blue pieces of glass:

1 -- red glass, 2 -- blue glass

Rays of light

Violet, Blue, Azure, Green, Yellow, Orange, Red

Figure 65. Diagram showing reflection of rays by an opaque body, having selective absorption in the blue-violet portion of the spectrum

V B A G Y O R

G Y O R

Figure 66. Color-mixing triangle

Green
Yellow Azure
White
Orange Blue
Red Purple Violet

Figure 67. Triangle of color mixing, inscribed in color circle

R
V Or
Blu Wh Y
A Y-G
G

Figure 68. Diagram showing how to obtain yellow ink by mixing yellow and azure inks, -- white light incident on a mixture of yellow and azure inks, -- yellow pigment, -- azure pigment, -- reflected white light, -- reflected yellow rays, -- reflected azure rays, -- binder

Paper

Figure 69. Diagram showing how green ink is obtained by superimposing yellow on azure.

-- reflected yellow-green rays, -- reflected green rays

Paper

Figure 70. Absorption curves of offset printing inks.

No 203 red, 275 red, 211 red, 104 orange, 212 red, 564 yellow,
216 red, 589 yellow, 219 red, 431 green, 229 red, 434 green,
232 red, 435 green, 363 azure, 342 blue, 364 azure, 345 blue,
355 azure (turquoise), 345 blue, 363 azure, 369 azure,
311 blue, 745 violet, 631 brown

Figure 71. Figure and background; it is possible to visualize the hatched figure on the white background and vice versa

Figure 72. Figure and background; the hatched figure is seen against the white background

Figure 73. Diagram showing technological process of preparation of line printing forms of the color proof of a classroom wall map.

Publication originals

Line	Line	Halftone
Negatives without individual elements	Negatives for legends	
Contours Horizontal Roads Other elements	Black Blue Others	Screen
Separation retouching of negatives	Separation retouching of negatives	Technical retouching
Preparation of printing forms for checking correctness of retouching		
Outlines Contours Horizontals Roads Other elem.	Black Blue Others	
Printing proofs		
Proofing correctness of separation retouching		
Correction of negatives		
Contours Horizontals Roads Other elements	Black Blue Others	
Preparation of printing forms for print proof		
Contours Horizontals Roads Other elements	Black	Wash-off relief
Printing the color proof		

Figure 74. Diagram showing calculation of the format of a paper sheet [signature] for publication of an atlas:

a, b -- dimensions of drawings of individual maps, u -- upper margin, l -- lower margin, f -- forward margin

Cleaning (trimming)

Cleaning

Cleaning

Gripper line
Cleaning

Figure 75. Schedule for preparation of line printing forms for the publication of a school atlas.

Publication originals

First Second Third Fourth etc

Montage of originals on printing sheet

Legend negative

Dismounting the legend originals

Initial line negative made with the wet-collodion method

Intermediate positive made by the wash-off relief method

For contours For hydrography For horizontals For roads etc

Separation retouching of negatives

Copying the forms for proofing the retouching

Outlines Contours Hydrography Horizontals Roads etc

Preparation of prints for proofing
Proofing and correction of negatives

Copying the printing forms for printing the color proofs

Contours Hydrography Horizontals Roads etc

Figure 76. Diagram showing arrangement of three maps, each repeated three times

Figure 77. Schedule of the duplication of repeating maps on a sheet.

Originals of different maps

A B C

Montage of originals (see Figure 76)

Preparation of wet-collodion negative montage,
containing the originals A+B+C

Triplicate copying from negative on the same silver-bromide
plate. Preparation of positive containing images I
(A+B+C), II (A+B+C) and III (A+B+C) (See Figure 76).

Preparation by contact and by wash-off relief of
the required number of working negatives

Retouching etc.

Figure 78. Schedule for obtaining composite negatives.

Publishers' Originals

First	Second	Third	Fourth
-------	--------	-------	--------

Negatives, prepared by the wet-collodion method

First	Second	Third	Fourth
-------	--------	-------	--------

Positives made on film

First	Second	Third	Fourth
-------	--------	-------	--------

Montage of positives on one glass and preparation
of composite positive

Working negatives, made by contact from the composite positive

Contour	Hydrography	Relief
---------	-------------	--------

Separation retouching of negatives etc.

Figure 79. Schedule for obtain composite line printing forms.

Publishers' originals

First	Second	Third	Fourth
-------	--------	-------	--------

Negatives prepared by wet-collodion method

Contour Hydro- Relief	Contour Hydro- Relief	Contour Hydro- Relief	Contour Hydro- Relief
graphy	graphy	graphy	graphy

Separation retouching	Separation retouching	Separation retouching	Separation retouching
-----------------------	-----------------------	-----------------------	-----------------------

Contour Hydro- Relief	Contour Hydro- Relief	Contour Hydro- Relief	Contour Hydro- Relief
graphy	graphy	graphy	graphy

Figure 79 continued

Preparation of composite printing form of contour by
copying from the four negatives

Preparation of two "phantom outlines" from the composite contour form

Preparation of the composite forms of the hydrography and relief by
combined copying on the "phantom outlines" with assembly of the contour
form from four negatives for each of the elements

Hydrography

Relief

Printing the proof of the line elements

Figure 80. Schedule for obtaining composite negatives through an
intermediate composite positive (using silver-bromide photo-
graphic plates).

Publishers originals

First	Second	Third	Fourth
-------	--------	-------	--------

Negatives made by the wet-collodion method

First	Second	Third	Fourth
-------	--------	-------	--------

Composite intermediate positive, obtained by contact
from the initial wet-collodion negatives

Working negatives, obtained by contact from the
intermediate positive

Contour

Hydrography

Relief

Separation retouching etc

Figure 81. Schedule for preparation of composite negatives, using
Viniprox and employing the wash-off relief method.

Publishers' Originals

First	Second	Third	Fourth
-------	--------	-------	--------

Negatives prepared by the wet collodion method

First	Second	Third	Fourth
-------	--------	-------	--------

Positives on Viniprox, obtained by wash-off relief

First	Second	Third	Fourth
-------	--------	-------	--------

Montage of positives on glass into one composite
positive

Figure 81 continued

Working negatives, obtained by contact from the composite positive using wash-off relief

Contour	Hydrography	Relief
Separation retouching of negatives etc		

Figure 82. Scheme for determining the percentage ratio of printing and blank elements on a crossed screen (on the printing form):

O_1 and O_2 -- percentage of opaque elements on the first and second screens, T_1 and T_2 are the percentage transparent elements on these screens.

O_1 T_1

O_2
 T_2